IMMERSIVE MEDICINE: AN INVESTIGATION OF A VIRTUAL REALITY INTERVENTION FOR SIMULATION-BASED MEDICAL EDUCATION

By
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Abstract

Simulation-based medical education (SBME) is a proven instructional method for increasing knowledge gains in medical learners. However, it is difficulty to implement because of cost, technical considerations, and issues of accessibility. This experimental, mixed-methods study of senior-level nursing students sought to understand what impact an immersive virtual reality (IVR) instructional delivery method would have on knowledge acquisition, clinical judgement skills, self-satisfaction and confidence when compared to traditional SMBE. Students in the experimental group were provided a supraventricular tachycardia (SVT) assessment skills curriculum delivered through IVR. Students in the control group were provided the same curriculum through traditional SBME using a high-fidelity mannikin. The researcher used a pre- and posttest for knowledge acquisition, observation of clinical judgement via the Lasater Clinical Judgement Rubric (LCJR), a self-satisfaction and confidence in learning questionnaire (SSLQ), and qualitative data collected from semi-structured interviews to determine the efficacy of the IVR instructional delivery method. Results from an independent t-test showed statistically significant differences in mean posttest scores between the IVR experimental group and the SBME control group, which suggested that the IVR delivery method had greater SVT knowledge acquisition than traditional SBME modality. Results of the LCJR and SSLQ showed that there were no significant differences between the two groups on clinical judgement performance or self-satisfaction and confidence. Qualitative data suggested that the students enjoyed the IVR experience, believed that it would be educationally beneficial to the nursing program, and that they would be able to enjoy repetitive practice in the location of their choosing.

Keywords: simulation-based medical education, immersive virtual reality, clinical judgement, supraventricular tachycardia

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The student has made all necessary revisions, and we have read, and approve this dissertation for submission to the Johns Hopkins Sheridan Libraries as partial fulfillment of the requirements for the Doctor of Education degree.

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Dedication

This dissertation is dedicated to all medical personnel who work—often at great personal risk—to care for others with healing hands, and glowing hearts. It is YOUR dedication to your profession that allows humanity to grow beyond what it is capable of—may you always have the best training and equipment at your fingertips.

I would also like to acknowledge my mother and father, Litsa and Roger Miller. Thank you for your life-long encouragement and allowing me to discover the magic in everything.

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Chapter 1 – Problem of Practice

Introduction

In the early 1900s, medical schools in the United States were unregulated. They had no certifications, admission standards, and most schools operated via an apprenticeship model (Drake, 2014). This lack of standards, coupled with the sheer proliferation of medical schools, raised concerns with the American Medical Association and the Association of American Medical Colleges. Thus, they actively sought help from the Carnegie Foundation, requesting an in-depth study of the state of medical education (Drake 2014). The result of the study was known as the Flexner Report, and among its recommendation for establishing standards was that medical schools should be affiliated with universities and that they should adhere to an academic model of education (Flexner, 1910). This university model of medical school education continues today, perhaps at the expense of providing students with more focused clinical time. A follow-up study by the Carnegie Foundation in 2010 is just now urging medical schools to provide students with integrated clinical experience and early clinical immersion before they earn their medical degree (Irby, Cooke, & O'Brien, 2010). The study also recommends that once students graduate medical school and enter their internship year of residency, they should have intense clinical exposure, with a focus on patient safety.

One of the goals of medical education is to increase patient safety through exposure to clinical scenarios (Patel, Yoskowitz, & Arocha, 2009). An effective way to accomplish this, while keeping the learners and patients safe, is through the use of medical simulations (Arora, Hull, Fitzpatrick, Sevdalis, & Birnbach, 2015). Thus, if medical simulations are not implemented in medical training institutions there is an immediate concern for student and patient safety in learning clinical skills (Kelly, Hopwood, Rooney, & Boud, 2016).

Simulation technology was first implemented by the military and commercial aviation industry to safely educate trainees (Rosen, 2008). As medical simulations have expanded over the last 10 years, so have the technologies involved in creating them. Medical simulations encompass manikins, with varying degrees of technical sophistication, computer and screen-based equipment, part-task trainers, human cadavers, and actors portraying patients (Cheng et al., 2014). These medical simulations have slowly gained traction in formal medical education curriculum, where simulations are the basis for practicing and learning clinical skills.

Simulation-based medical education (SBME) is defined as using simulations (e.g., manikins, virtual environments, simulated patients) for educating and preparing students for work in a clinical setting (Ahmed, Al-Mously, Al-Senani, Zafar, & Ahmed, 2016). (Add transition word) In this way, SBME has been researched as an effective means for medical students to learn and acquire clinical skills (Cook, Brydges, Zendejas, Hamstra, & Hatala, 2013; Issenberg, Mcgaghie, Petrusa, Gordon, & Scalese, 2005; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011). SBME is closely linked to problem-based learning (PBL). PBL is a method of instruction that has its origins in medical education (Boud & Feletti, 1997). At its core, PBL is a student-centered method of instruction where learners use theory and applied knowledge toward solving a problem (Savery, 2015). Combining PBL with SBME has received scholarly attention, and there is a presupposition of the combination's effects on motivation (Maruyama & Inoue, 2016).

Medial schools and teaching hospitals that have implemented SBME into their curriculum have improved the educational outcomes of students. SBME can safely and effectively teach students procedural skills (Khunger & Kathuria, 2016) communication skills (Lewis, Strachan, & Smith, 2012) geriatric medicine (Fisher & Walker, 2013) resource management skills (Datta, Upadhyay, & Jaideep, 2012) and increase confidence (Donkers, Bednarek, Downey, & Ennulat, 2015) all while allowing students to make mistakes and learn from failures (Akaike et al., 2012).

Problem of Practice

SBME is a safe and effective teaching method that can bridge the gap between the classroom and the clinical environment. However, it has not been implemented into the curriculum in all medical schools and teaching hospitals (Huang et al., 2012). Teaching institutions may see the scope of a simulation lab as narrow, offering only hands-on practice for learners, and not recognizing the wider applications (King, Moseley, Hindenlang, & Kuritz, 2008). Barriers to SBME include: a lack of a pedagogical model that uses theory and evidence-based best practices (Kelly, Hopwood, Rooney, & Boud, 2016), the time commitment required by faculty and students (Eppich et al., 2013), confusion over fidelity (Tun, Alinier, Tang, & Kneebone, 2015) and the cost of implementation (Chinnugounder , Hippe, Maximin, O'Malley, & Wang, 2015; Eppich et al., 2013).

SBME is not fully integrated in the simulation lab at the University of Nebraska Medical Center (UNMC), where the expansion of the simulation program is challenged by issues of cost, faculty training, evidence-based best-practices for instructional design, and curriculum integration. The technology, equipment and space needed for SBME is expensive, and the costs prohibit all students from taking advantage of the lab on their own schedule. Faculty training is also a problematic factor because not enough resources are allocated for professional development. This results in neglecting the application of evidence-based best practices that can improve SBME outcomes. Also, simulation education is in a separate space where learning and assessment are isolated in the lab instead of part of a curriculum that is integrated with other educational experiences. If quality SBME experiences are not available to medical students, then they cannot adequately learn and practice medical skills—the safety of both the students and their patients are at risk.

Theoretical Framework

The theoretical framework for this literature review adopts Neal and Neal's (2013) conceptualization of a networked ecological systems theory (EST). Bronfenbrenner's (1994) ecological systems theory viewed human development as occurring across time through the interactions, known as proximal processes, between an individual and the environment. In Bronfenbrenner's model, the environment is conceptualized as a nested model consisting of macro-, exo-, meso-, micro-, and chronosystems, with a focal individual at the center of the nest. Neal and Neal (2013) argue that the systems in EST are naturally not nested, but rather overlapping systems that are influenced by social interactions. The authors define the setting of EST through these social interactions and thus focus on the interconnections between the systems and the individuals or groups involved. In this revised ecological system, the

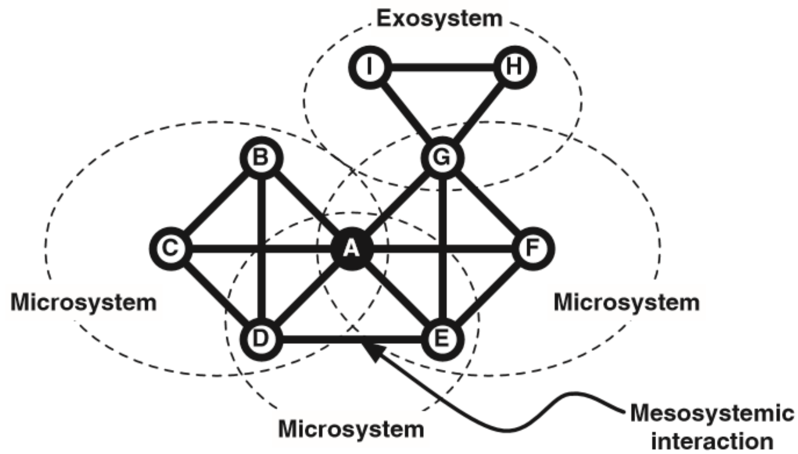

Figure 1.1. Neal and Neal's networked model of ecological systems, focused on person A. Reprinted with permission from "Networked or Nested? Future Directions for Ecological Systems Theory," by J. W. Neal and Z. P. Neal, 2013, *Social Development, 22,* p. 728. Copyright 2013 by John Wiley & Sons Limited.

microsystem is the immediate setting that comprises the focal individual with direct interaction, the mesosystem is the social interaction that connects different settings to the focal individual, and the exosystem is a setting that does not include the focal individual but can indirectly influence the individual through the social interactions of the participants. This model more clearly illustrates the mesosystems of the EST model and how each ecological system is connected to one another and the focal individual. For example, the focal individual may be the student, the social interactions between the student microsystem and the faculty microsystem comprise the mesosystem, and is further influenced by the exosystem of the school's administration. Though the student and the administration may not have a direct interaction, school policy influences the teacher through a mesosystemic interaction.

However, this study conceptualizes SBME as a biotic species in the ecological system, and specifically as the focal individual in the EST model. The precedence for establishing an inanimate entity as a living species was set by Zhao and Frank's (2003) ecological perspective of factors affecting technology use in schools. The authors argued that technology, though not an organism in the traditional sense, has an evolutionary component that is similar to that of a living species and that this ecological metaphor can be applied to technology adoption. The authors used this model to show that the successful adoption and use of technology in schools is multifactorial, that these factors cannot be examined in isolation, and that the factors should be studied together in a framework that situates technology use as a central species in the biotic ecosystem. The authors applied this framework to study the use of technology in 19 schools and found that technology use and adoption is coevolutionary with the school and its success or failure is dependent on the dynamic interactions of influential factors.

In this view, the focal entity is SBME because its implementation is heavily reliant upon the use of technology, and its successful implementation is determined by a host of factors which are influenced by their relationships to one another. Using these theoretical frameworks, SBME is positioned as the focal biotic individual in the ecological system, with students and faculty each forming a microsystem. This microsystem includes SBME and an exosystem of policy that influences administrative and teacher behaviors.

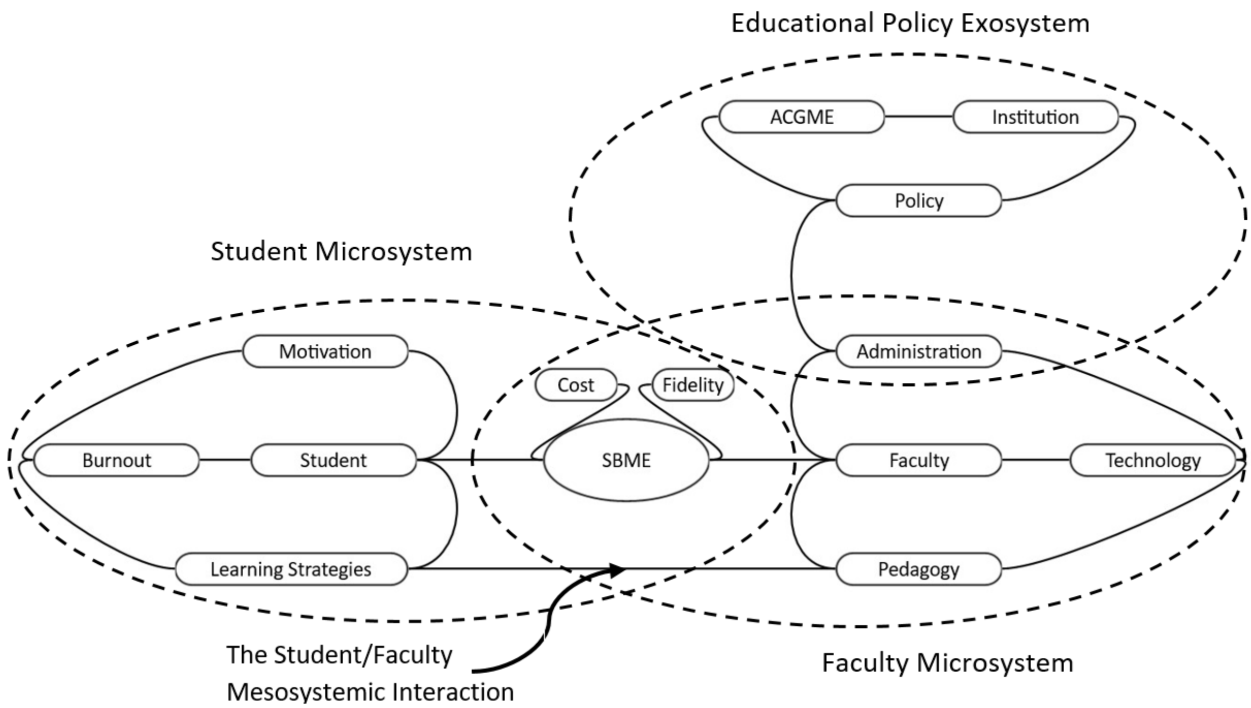

Figure 2.1. SBME as the focal, biotic individual in a networked model. Adapted with permission from "Networked or Nested? Future Directions for Ecological Systems Theory," by J. W. Neal and Z. P. Neal, 2013, *Social Development, 22,* p. 728. Copyright 2013 by John Wiley & Sons Limited.

The exosystem also includes the social interactions between institutions, the accrediting body, and the administration. Rather than containing *school* as a term, the ecosystem contains *institution* to encompass medical schools, university medical centers, and teaching hospitals—places where SBME is used to teach students. The mesosystem comprises institutional culture and is the connection between the two microsystems. Conceptualizing SBME and the factors that influence successful implementation with these theoretical frameworks will help situate the problem from a holistic perspective.

Factors Related to SBME Implementation

Using this networked ecological model with SBME as the focal individual, the literature review will first look at the educational policies, environment, and culture that indirectly affect SBME and contribute to the problem. Next the literature review will explore the student and faculty microsystems and the barriers that threaten successful SBME implementation. Last, will be a review of literature that discusses barriers endemic to SBME, namely cost, fidelity, and pedagogical challenges that are the justification for focusing a needs assessment on these factors.

Educational Policy Exosystem

In order for SBME to be successful, it must include skilled educators that are trained to use the simulators (Dieckmann, Friis, Lippert, & Østergaard, 2012). However, one of the barriers to SBME implementation is that faculty do not have enough protected time to adequately train with the equipment (Al-Ghareeb & Cooper, 2016). The reasons for the lack of protected time are a combination of exosystemic influences, namely policy, learning environment, and cultural norms.

Policy. The Accreditation Council for Graduate Medical Education (ACGME, 2017) is an organization that develops a list of standards that United States graduate medical education programs need to follow to receive accreditation. The organization oversees programs for residents—medical students that have graduated from medical school and are continuing their medical education by training in a specialty. One of the requirements for accreditation is that residents are limited to a maximum of 80 hours per week for clinical and educational work (ACGME, 2017). This limitation, while intended to protect the safety of residents and patients, has the unintended consequence of increasing the amount of time that faculty has to spend caring for patients (Bandiera, Hynes, & Spadafora, 2014). The extra time that faculty spend working results in a reduction of time for nonclinical obligations such as teaching and training (Jamal et al., 2011). This problem is exacerbated by the need for faculty to stay productive. To maintain their salaries, faculty must spend time engaging in scholarly pursuits such as research and publishing as well as clinical work, which marginalizes their educational role (Lowenstein, Fernandez, & Crane, 2007).

Another policy affecting SBME is increasing class sizes. As the general population ages and physician shortages continue, medical schools have increased their student class sizes to accommodate future demand (Salsberg & Grover, 2006). While increasing class sizes is intended to educate more students, it also makes it harder to recruit teachers and offer more protected time for teacher training (Hemmer, Ibrahim, & Durning, 2008). Without trained teachers, SBME cannot function effectively (Dieckmann, Friis, Lippert, & Østergaard, 2012). In addition, faculty at medical schools are required to supervise all medical students during clinical experiences (Liaison Committee on Medical Education, 2017).

These policies have made it more difficult for faculty to find time to not only train using simulation equipment, but improve and strategize teaching practices. Time is not the only competing factor to successful SBME implementation. There are also cultural concerns that influence faculty involvement in education.

Cultural influencers and attrition. The successful implementation of SBME relies on trained faculty. When faculty are dissatisfied with their jobs, the educational environment does not operate at an optimal level. Faculty dissatisfaction is related to culture, both at a societal level and an institutional one.

One of the challenges that institutions face is training and retaining qualified female faculty. This is a concern because the majority of faculty at medical schools on the clinical-educator track are female (Mayer et al., 2014). Female faculty at medical schools view the culture of the school as being male-dominant and that this results in salary inequities and the perception that academic resources are not fairly distributed (Carr, Gunn, Kaplan, Raj, & Freund, 2015). This cultural climate of gender inequality makes it difficult to hire and train faculty to educate students (Valantine & Sandborg, 2013) and is a source of female faculty attrition (Deutsch & Yao, 2014). Cultural issues that influence faculty training and retention are also evident at an institutional level.

Faculty attrition is an existential threat to institutions with an academic mission. If faculty leave these institutions, the successful implementation of SBME is in jeopardy. When the administration does not support a cultural climate of teaching, faculty are more likely to leave (Bucklin, Valley, Welch, Tran, & Lowenstein, 2014). In contrast, when the learning environment is supported by the institution's culture, not only does faculty attrition improve, but individual faculty's teaching performance does as well (Lombarts, Heineman, Scherpbier, & Arah, 2014). Faculty dissatisfaction can be the result of a mismatch between the institution's vision and the views and actions of administrators and faculty (Bland, Seaquist, Pacala, Center, & Finstad, 2002). For example, the medical institution may have a vision for growth in the next five years, with policy decisions that help shape that growth. However, when this vision and the concurrent polices are not effectively communicated to the faculty, there can be discord and discontent. This disparity between competing visions of administration and faculty is a contributing factor to faculty attrition (Pololi, Dennis, Winn, & Mitchell, 2003).

School climate is also a factor affecting attrition. A medical school climate that recognizes the need for balance between work and family is more successful at retaining medical faculty, especially women (Shollen, Bland, Finstad, & Taylor, 2009). Other climactic factors that contribute to attrition include lack of opportunities for career advancement, a poorly defined salary structure, and departmental leadership issues (Cropsey et al., 2008). This issue of culture and climate is one that influences the entire ecosystem, and is a foundational structure of the faculty and student microsystems.

Student Microsystem

SBME is designed to teach students a variety of skills related to becoming a competent physician (Issenberg et al., 2005). The ACGME guidelines require that students use simulation in general surgery and anesthesiology (Hamstra & Philibert, 2012). and the accrediting body for medical schools in the United States has standards that require simulation training to supplement clinical exposure (Liaison Committee on Medical Education, 2017). However, students that are training to become doctors face important challenges that affect their ability to learn and participate in simulation training.

Motivation in medical education. Students who are intrinsically motivated engage in deeper learning and have improved learning outcomes (Kusurkar, Croiset, Galindo-Garré, & Ten Cate, 2013). However, student motivation gets little attention in the planning of medical curricula (Kusurkar, Croiset, Mann, Custers, & Ten Cate, 2012). The dominant pedagogical approach in medical education is PBL and it continues to grow as a teaching strategy (Savery, 2015). It has been argued that PBL in medical education does not improve learning outcomes and is costlier (Kirschner, Sweller, & Clark, 2006). Studies also show that PBL can distract students and decrease intrinsic motivation (Duke, Forbes, Hunter, & Prosser, 1998; Zimmerman & Campillo, 2003). Despite these findings, new studies have called for a combination of SBME and PBL in medical education (Maruyama & Inoue, 2016; Kang, Kim, Kim, Oh, & Lee, 2015). The push to combine PBL with SBME stems from the increased use of technology in medical education. Combing technology with PBL leads to gains in medical expertise, and provides an integrated forum for collaboration (Jin & Bridges, 2014).

Stress, anxiety, and burnout. Not only do medical students have to contend with academic issues to be successful, but they have to find ways to manage non-academic challenges like sleep deprivation, language barriers, and stress (Abdulghani et al., 2014). Sleep deprivation is characterized by measurements of subjective sleep quality, duration, habitual sleep efficiency, and daytime dysfunction (Pagnin et al., 2014). Students who are sleep deprived experience greater occurrences of cynicism and lower incidents of academic efficacy, both of which contribute to burnout (Pagnin et al., 2014). For international students, language barriers hinder a student's ability to communicate effectively with faculty, staff, and patients, and can negatively affect academic performance (McKenna, Robinson, Penman, & Hills, 2017). Language barriers may also make it difficult for these students to navigate mental health resources (Dyrbye et al., 2015). Stress has been identified as a major contributing factor to burnout (Dyrbye & Shanafelt, 2016). Though stress is a multifactorial construct, one key instigator of stress in medical students is their transition from didactic lessons to clinical training (Brennan et al., 2010).

These challenges, if unmanaged, can lead to burnout, which is a construct consisting of emotional distress, detachment, and feelings of worthlessness (Maslach, Jackson, & Leiter, 1996). When medical students first enter medical school, they have lower incidences of depression and burnout compared to their peers (Brazeau, Shanafelt, Satele, Sloan, & Dyrbye, 2014). However, shortly after beginning their studies, burnout prevalence continues to increase until it is greater than that of peers not in medicine (Dyrbye & Shanafelt, 2016; Dyrbye et al., 2014). Students who exhibit high rates of burnout and a lower quality of life are also the least intrinsically motivated in academic pursuits, have low self-efficacy, and higher test anxiety (Lyndon et al., 2017).

The stress levels of students are highly correlated with the number of stress sources, and highly correlated with lower academic performance (Sohail, 2013). The sources of stress that lead to burnout are workload (Dyrbye & Shanafelt, 2016), mistreatment by faculty (Cook, Arora, Rasinski, Curlin, & Yoon, 2014) and other work-related factors such as an unsupportive environment (Dyrbye & Shanafelt, 2016). As burnout influences academic performance, the successful implementation of SBME is dependent on students' psychological well-being (Dieckmann et al., 2012) as well as factors associated with the SBME biotic system.

SBME

When SBME is conceptualized as a biotic system there are certain traits and characteristics inherent in its makeup that present challenges to its survival in an ecosystem. Zhao and Frank (2003) saw technology in an educational ecosystem as an invasive species that could either supplant itself in the environment, adapt, or fail to thrive. Similarly, SBME has attributes that make it difficult to survive in the medical education ecosystem. These attributes are cost, fidelity, and the pedagogical model. These three factors are within the microsystem of SBME and are central to the problem of practice.

Cost of implementation. In a networked EST model, cost would be a characteristic that directly affects the SBME ecological system. The implementation of SBME into a medical education curriculum has been identified as a costly endeavor (Chinnungounder et al., 2015). The associated costs can be prohibitive, especially for smaller institutions that function on a smaller operating budget, and lack of financial support is a major barrier to implementation (Bahner, Goldman, Way, Royall, & Liu, 2014). In addition to a lack of financial support, insufficient storage space and a dearth of simulator equipment have been identified as significant barriers (Eppich et al., 2013). The high costs of simulation place an extra financial burden on medical schools that are already trying to find ways to increase revenue and allocate finances. The Association of American Medical Colleges recognized a shortage of physicians and called for a 30% increase in supply through the expansion of class size and medical schools (Rabinowitz, Diamond, Markham, & Wortman, 2008). The annual variable cost to educate a medical student, however, exceeds the revenue from tuition and fees, and medical schools have to find new financial sources to remain viable (Schieffler, Azevedo, Culbertson, & Kahn, 2012).

Given these findings, institutions wanting to integrate simulation into their curriculum would benefit from cost-analysis studies regarding simulation. Despite the evidence that cost is a barrier, there is a gap in the literature in determining the cost effectiveness of simulation. Determining whether simulation is cost-effective is essential to informing purchasing decisions for new equipment and staff. In a systematic review, Zendejas, Wang, Brydges, Hamstra, and Cook (2013) looked at 967 articles on simulation that mentioned cost and found that only 6.1% reported cost elements, while only 1.6% of those studies had a cost analysis comparing the cost of simulation to other teaching methods.

The few studies that do provide a cost analysis have limitations. In a comparison of various simulation modalities, Isaranuwatchai, Brydges, Carnahan, Backstein, and Dubrowski (2013) used a net benefit regression model to conclude that a simulation program integrating a variety of progressive methods from low-fidelity computer simulations to high-fidelity manikins was more cost effective than using manikins alone. However, the study was done at only one institution and on only one cohort of students, which negatively affects its generalizability. Similarly, a recent study by Bosse, Nickel, Huwendiek, Schultz, and Nikendei (2015) found that using peer role-play as a substitute for standardized patients in simulation scenarios was more cost effective, however the study only looked at a 2-week time period and did not factor in associated costs over the long term. The reason why this gap in the literature exists may be due to the influences of so many different stakeholders, as well as educational research being grounded in qualitative methods (Maloney & Haines, 2016).

Disagreement about fidelity. Another characteristic of the SBME microsystem is fidelity. Closely linked to cost, fidelity as it applies to SBME is the "the degree to which the trainee perceives the simulation to be authentic or real by 'suspension of disbelief'" (Kalaniti & Campbell, 2015, p. 43). For example, manikins that are connected to computers, can show chest expansion, create breath sounds and have the ability for venous puncture are considered high-fidelity, whereas manikins that are devoid of technology and have limited or no movement are considered low-fidelity. However, Tun et al. (2015) have shown that the definition is not used consistently and is problematic because it assumes that replication rather than representation of reality is the goal of fidelity. This results in the misconception that technologically advanced simulators are the most desirable and that other aspects of fidelity, such as environmental, and psychological fidelity are unimportant (Tun et al., 2015). The focus on high-fidelity simulators thus becomes a focus on ever-increasingly advanced technologies that are more expensive to purchase, implement, and maintain (Scerbo & Dawson, 2007). This narrow definition of fidelity contributes to studies that are inconsistent in determining which model of fidelity, low or high, leads to improved educational outcomes.

When comparing low-fidelity (LF) with high-fidelity (HF) simulation modalities, there are conflicting results. Some studies show LF is perceived as superior to HF simulations (Davoudi, Wahidi, Rohani, & Colt, 2010; Tosterud, Hedelin, & Hall-Lord, 2013). Other studies show that HF simulations are superior both in the perception of the students and in performance measures such as cognitive and behavioral as well as procedural skills (Butler, Veltre, & Brady, 2009; Crofts et al., 2006; Hoadley, 2009). Still other studies show that there is no difference in academic performance measures between LF and HF (Curran et al., 2015; Norman, Dore, & Grierson, 2012).

Despite assumptions that HF simulations increase perceptions of realism, biological indicators of stress showed no difference for students in LF versus HF neonatal resuscitation scenarios (Finan, Bismilla, Whyte, LeBlanc, & McNamara, 2012). Deciding whether LF or HF is appropriate to the learning objectives and specific scenarios is fundamental to overcoming the challenges of fidelity and its associated costs (Munshi, Lababidi, & Alyousef, 2015). Thus, application of LF and HF simulations in SBME is dependent on the pedagogical model.

Underutilization of evidence-based best practices. Using simulations in a controlled environment to educate students is experiencing continued growth (Qayumi et al., 2014), but it does not lead to learning simply by applying without regard to theory and teaching strategies (Hopwood, Rooney, Boud, & Kelly, 2016). In an effort to move beyond opinion-based applications, The Best Evidence Medical Education (BEME) collaboration is an international group that seeks to apply evidence-based, best practices and teaching strategies to medical education (Harden, Grant, Buckley, & Hart, 2000).

In a seminal BEME systematic review, Issenberg et al. (2005) identified 10 features of simulations that lead to effective learning. These features include strategies such as debriefing, repetitive practice, and individualized learning (Issenberg et al., 2005). Despite the review's impact on SBME research, the complexities of designing a successful SBME program and the application of research to practice, results in an underutilization of these features (Lazzara, Benishek, Dietz, Salas, & Adriansen, 2014; Motola, Devine, Chung, Sullivan, & Issenberg, 2013). Three of these important features have been identified as essential to improving educational outcomes, yet there is evidence that their application in SBME is underutilized.

Limited debriefing. Debriefing is a process of feedback after a learner has completed a simulation scenario and is an effective strategy to improve both technical and non-technical skills (Fanning & Gabba, 2007; Levettt-Jones & Lapkin, 2014). However, there is no consensus on the most effective ways to integrate debriefing into SBME curriculum (Cheng et al., 2016; Decker et al., 2013; Lyons et al., 2015). Moreover, SBME educators continue to encounter difficulties when trying to apply the process and need extra support (Eppich & Cheng, 2015). Educators who did not receive debriefing support, or were unfamiliar with its application, did not use debriefing at all (Waznonis, 2015). In a review of simulation programs by Doughty et al. (2015) only 24% of the programs had a debriefing curriculum.

No time for repetitive practice. Integral to the success of SBME is for students to engage in continual, deliberate practice (Motola et al., 2013). Repetition and practice can improve procedural skills acquisition (Bosse et al., 2015; Chee, 2014). The more time that students spend practicing in simulation scenarios has a positive correlation with improved learning outcomes (McGaghie, Issenberg, Petrusa, & Scalese, 2006). However, students are not afforded the opportunities for repetitive practice (Price, Price, Pratt, Collins, & McDonald, 2010). For students to practice their skills, they need to be able to schedule time with the simulators and have access to equipment (Dieckmann et al., 2012). However, lack of time, an insufficient number of manikins, and limited simulation space prevent them from doing so (Al-Ghareeb & Cooper, 2016).

Lack of individualized learning. Individualized learning is not merely a self-directed model for knowledge acquisition, but rather learning where simulations are adapted to a learner's specific needs and account for differences in learning styles and prior knowledge (Issenberg et al., 2005). Individual learning plans are preferred by medical students and can help them improve and prioritize learning outcomes (Guardiola, Barratt, & Omoruyi, 2016). Medical students also prefer to use multiple learning styles, providing further evidence for the need to individualize learning (Lujan & DiCarlo, 2006).

Despite the benefits of individualized learning, it is not an inherently supported feature of simulations (Keskitalo, Ruokamo, & Gaba, 2014). In a survey of simulations that used best practices in instructional design, individualized learning was the least supported feature and found to be present in only 4% of the studies (Cook et al., 2013). For SBME to be successfully integrated, the application of evidence-based pedagogical features need to be present.

Summary

The barriers to successful SBME implementation are multifactorial and span the entire ecosystem of policy, students, faculty, and simulation characteristics. Integrating SBME into the curriculum at institutions is a very costly endeavor (Chinnugounder et al., 2015). It requires a considerable financial investment to provide equipment, storage and lab space, trained faculty, and maintenance (Eppich et al., 2013). A simulation's ability to represent reality is also of concern since HF simulators are more expensive to buy and maintain, and time-consuming to implement (Scerbo & Dawson, 2007). Another important barrier is the failure of SBME programs to apply evidence-based best practices into simulation pedagogy (Motola et al., 2013). The presence or absence of evidence-based best practices and student and faculty perceptions of fidelity in the context at UNMC will be the focus of a needs assessment.

Chapter 2 – Needs Assessment

Needs Assessment Data Collection Report

Simulation-based medical education (SBME) is defined as using manikins, virtual environments, and simulated patients for the purpose of educating and preparing students for work in a clinical setting (Ahmed, Al-Mously, Al-Senani, Zafar, & Ahmed, 2016). SBME has been shown to be an effective means for medical students to learn and acquire clinical skills (Cook et al., 2013; Issenberg, Mcgaghie, Petrusa, Gordon, & Scalese, 2005; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011). Not only is SBME an effective modality, it also keeps the learners and patients safe by allowing students to practice skills without the risk of harming patients (Arora, Hull, Fitzpatrick, Sevdalis, & Birnbach, 2015). However, SBME has not been implemented into the curriculum in all medical schools and teaching hospitals (Huang et al., 2012). Teaching institutions may see the scope of a simulation lab as narrow, offering only hands-on practice for learners and not recognizing the wider applications such as communication and team-building skills (King, Moseley, Hindenlang, & Kuritz, 2008). Barriers to SBME include: (a) a lack of a pedagogical model that uses theory and evidence-based best practices (Kelly, Hopwood, Rooney, & Boud, 2016), (b) the time commitment required by faculty and students (Eppich et al., 2013), (c) disagreement over fidelity (Tun, Alinier, Tang, & Kneebone, 2015) and (d) the cost of implementation (Chinnugounder et al., 2015; Eppich et al., 2013). These are all issues that are reflected in the simulation lab at the UNMC that educates 3,861 students in a wide variety of medical specialties.

The idea of fidelity in simulation, or the adherence of the teaching scenario to real life events (Finan, Bismilla, Whyte, Leblanc, & McNamara, 2012), was observed as problematic during several instances because students could not suspend their disbelief and commit to the scenario as if it were real. Examples include laughing at inappropriate times, looking at a phone, or being disengaged from the action, activities that would not occur during a real medical situation. A study by Curran et al. (2015) showed that high fidelity in simulation scenarios is positively correlated with improved confidence and self-efficacy scores of students when there is a suspension of disbelief. However, in every observed scenario, there were instances when belief was suspended.

In addition to the students being disengaged, there were technical issues that decreased the fidelity. In the rapid response simulation at UNMC, the laptop that was simulating a heart rate monitor showed that the patient had a pulse, but the manikin's pulse simulator was not working. This was a technical problem that altered the way the students were learning about resuscitation in the scenario. Similarly, in the OBGYN simulation, fidelity issues manifested when the legs of the manikin would not stay in a normal anatomical position, which resulted in nervous laughter from the students. On multiple occasions during the scenario, the instructor remarked that this was not real life in referring to how easy it was to deliver the baby manikin. The flaccidity of the manikin was also described as unrealistic. Another observed issue related to fidelity was the use of the defibrillator. Students had to mimic the setup and usage of the equipment, because a student in a previous simulation had shocked the manikin and subsequently fried the manikin's computer software, a very expensive mistake. Curran et al. (2015) found that the absence of fidelity led to significantly lower scores of students' satisfaction ratings, this might provide evidence as to why some of the students in the simulations were not engaged.

Though most students seemed to be engaged in the simulations, some appeared to be uninterested as observed through their body posture, lack of active involvement, and looking at their phones during the scenario. In the OBGYN simulation at UNMC, the students had to deliver a baby manikin from a simulated mother. The first student to complete the delivery asked if she had to stay and watch the other students, because there was a high-stakes test she was studying for. A student participating in the rapid response simulation abruptly left after the first scenario was complete. Jansen, Johnson, Larson, Berry, and Brenner (2009) found that the time commitment required of students was a barrier to SBME integration, and these observed instances were indicative of the study's findings.

Another observation was the inconsistent application of a pedagogical model. Debriefing after SBME has been shown to increase educational outcomes (King, Conrad, & Ahmed, 2013; Cheng et al., 2016), yet one simulation had a limited debriefing in the same room, one simulation debriefed in a separate conference room after each scenario, and another simulation did not debrief at all. This observation was consistent with the Decker et al. (2013) study that found a lack of pedagogical consistency and theoretical grounding in SBME integration. The students in the SVT simulation at CHO were all nurses from various backgrounds and one of the nurses was a clinical nurse with no exposure to a hospital setting, the crash cart, and defibrillator equipment. The prior knowledge of these students was not taken into consideration as they were all taught the same curriculum in a group setting. This is antithetical to constructivist learning theory where a student's prior knowledge affects knowledge acquisition and transfer (Piaget, 1952).

In addition to these observable challenges, there are also some challenges identified in the literature. A systematic review by Issenberg et al. (2005) used a best-evidence in medical education framework to determine which features of SBME lead to improved educational outcomes. The authors identified 10 features that contribute to a more robust educational experience for students. Using this framework, the needs assessment will look at some specific features that have received the most attention in the literature—the use of debriefing, repetitive practice, individualized learning, and range of difficulty.

Another challenge centers on the concept of fidelity. Fidelity is the degree to which a simulation—the technology, scenario, environment—represent a real-world clinical scenario, both physically and psychologically (Tun et al., 2015). There is disagreement in the literature over which level of fidelity, low or high, leads to better outcomes. As discussed in chapter one, when comparing low-fidelity (LF) with high-fidelity (HF) simulation modalities, some studies show LF is superior to HF simulations (Davoudi, Wahidi, Rohani, & Colt, 2010; Tosterud, Hedelin, & Hall-Lord, 2013). Other studies show that HF simulations are superior both in the perception of the students and in performance measures such as cognitive and behavioral as well as procedural skills (Butler, Veltre, & Brady, 2009; Crofts et al., 2006; Hoadley, 2009). Still other studies show that there is no difference in academic performance measures between LF and HF (Curran et al., 2015; Norman, Dore, & Grierson, 2012).

There is also a challenge that concerns the cost of SBME implementation. The implementation of SBME into a medical education curriculum has been identified as a costly endeavor (Chinnungounder et al., 2015). The associated costs can be prohibitive, especially for smaller institutions that function on a smaller operating budget, and lack of financial support is a major barrier to implementation (Bahner, Goldman, Way, Royall, & Liu, 2014).

These barriers are evident in the context of UNMC, where the expansion of the simulation program experiences issues of high cost, lack of faculty time and training, technological challenges, and the underutilization of evidence-based, best-practices for instructional design. If simulation use is not available to medical students, then they cannot adequately learn and practice medical skills—the safety of both the students and their patients are at risk.

Goals and Objectives

The goals and objectives of this needs assessment center around three areas of inquiry. The first of these objectives is to explore the use of evidence-based best practices in simulation pedagogy within the context at UNMC. The needs assessment is designed to see if these features of simulation are being employed within the research context. Second, the needs assessment has a goal of determining the perceptions of both faculty and students regarding fidelity. The needs assessment will examine student and faculty perceptions of fidelity within the research context and whether faculty and students feel that observed simulations adequately represent real-world clinical scenarios. Finally, the needs assessment seeks to determine the costs of implementing SBME in the research context at UNMC. To guide this study, three focused research questions were developed:

RQ1	In what ways are medical simulations applying evidence-based best practices and teaching strategies?
RQ2	To what degree are high-fidelity simulations perceived as replicating real-world clinical scenarios?
RQ3	What is the cost of implementing simulations within the research context?

Methodology

Situating these research questions within a problem of practice and review of literature led to the development of a mixed methodology that uses quantitative and qualitative data to understand the challenges that faculty and students experiencing during SBME training. The reason a mixed methodology was chosen was that faculty and student perceptions are just as important as the quantitative data that gives a holistic picture of SBME challenges and associated costs. The following sections will look at the participants, measures, data collection, and data analysis.

Participants

Surveys were emailed to two different groups of participants. The first group was 98 first-year medical residents. Of the surveys emailed, 15 were returned. They are at a transitional level where they are expected to dramatically increase their knowledge and skills in clinical settings, while at the same time having their first encounters in real-world scenarios.

The second group was 32 simulation faculty instructors at UNMC. Of the 32 surveys emailed, 13 were returned for a 40% response rate. The average age of the faculty respondents was 30 years. Just over half of the respondents (58%) were female and the majority of respondents listed a medical doctor (MD) as the highest earned degree. Most of the respondents had been simulation instructors for less than five years, while a few (16%) had taught for more than 10 years. More than half of the respondents (58%) had never had a continuing education course on simulation.

Measures

One of the concepts measured is the inclusion or absence of evidence-based best practices and teaching strategies in SBME. A Best Evidence in Medical Education review by

Issenberg et al. (2005) identified important features of SBME that lead to increased educational outcomes. The identified strategies that have been operationalized are (a) feedback, (b) range of difficulty, (c) multiple learning strategies, and (d) repetitive practice. These strategies were measured in Part A of the faculty survey instrument.

Table 2.1

Faculty Needs Assessment Sample Questions Part A

Construct	**Number of Items**	**Survey Question**
Feedback	12	I regularly listen and make people feel heard.
Range of Difficulty	2	Simulations allow me to offer a range of difficulty to the participants.
Multiple Learning Strategies	4	Simulations are structured to allow individual, independent learning, without an instructor.
Repetitive Practice	5	I have enough time to facilitate the repetitive practice of participants.

Another concept assessed was fidelity. Six questions were derived from Tun et al's (2015) operationalization of fidelity and contained in Part B of the faculty survey. Table 2.3 contains a sample question from this section.

Table 2.2

Faculty Needs Assessment Sample Questions Part B

Construct	Number of Items	Survey Question
Fidelity	6	Simulations have a high degree of accuracy in representing real-world clinical environments.

The final construct in this study is cost. The cost of implementation includes simulation equipment and manikins, maintenance, storage facilities, support staff and faculty and has been identified as a major barrier to successful implementation of SBME (Chinnugounder et al, 2015; Eppich et al., 2013). This construct will be measured through the procurement of secondary financial data that exist in the research context. The financial data collected will provide information about the cost of the equipment and the range of salaries for the support staff.

Data Collection Methods

Two Likert scale survey instruments were used in this needs assessment. These instruments were designed to measure the constructs outlined in the previous section. The face validity of the instruments was achieved through a review by two practicing physicians, both with over ten years of simulation experience. Both survey instruments were created in Qualtrics. Data were collected and stored in Qualtrics on a password-protected computer. One survey was sent to the director of clinical simulations at UNMC who emailed the survey to faculty and instructors that facilitate SBME scenarios. The other survey was sent to the director of residents at UNMC who emailed the survey to all first-year. It was decided that if the survey email came from the director, the residents would be more likely to respond to the survey. The survey instruments were also sent to two first-year medical residents to pilot test and their feedback was incorporated into the final question design. Data from the surveys were collected and analyzed in Qualtrics. The financial data for the cost construct was requested and obtained via an email to the executive director of clinical simulations at UNMC, who has access to the financial data of the simulation labs.

Initial Summary of Results

The needs assessment report will now look at some key findings related to each construct operationalized in the faculty survey.

Research Question 1

In what ways are medical simulations applying evidence-based best practices and teaching strategies?

How do instructors use feedback? The results of the survey revealed that faculty agreed they provided students with appropriate feedback before, during, and after simulations. The strongest numbers (81%) believed that they regularly guided conversations so that the conversations progressed logically, while all faculty (100%) agreed that they listened and made people feel heard. A surprising finding was that just under half of faculty (45%) indicated that they did not regularly use video or recorded data to support analysis. This is interesting because video is considered the gold standard in debriefing feedback; it has been found to enhance the accuracy of the debriefing process (Grant, Moss, Epps, & Watts, 2010). Another interesting finding was that the majority of faculty (73%) did not agree that they had enough time to facilitate a rich debriefing experience with simulation participants. Table 2.4 shows the use of video or recorded data to facilitate debriefing, separated by gender to show that females were more likely to use video or recorded data to support feedback.

Table 2.3

Percentage of Faculty Using Video or Recorded Data to Support Feedback

Category	n	Strongly Disagree n (%)	Disagree n (%)	Agree n (%)	Strongly Agree n (%)
Male	4	1 (25)	1 (25)	1 (25)	1 (25)
Female	7	2 (29)	1 (14)	1 (14)	3 (43)
Total	11	3 (27)	2 (18)	2 (18)	4 (36)

Do instructors offer participants a range of difficulty in curriculum? There were two items that measured faculty's perceptions of offering students a range of difficulty during simulation scenarios. Most of the faculty (82%) agreed that they understood the proficiency levels of the participants prior to running the simulation scenarios. An even higher percentage of faculty (91%) felt that simulations allowed them to offer a range of difficulty to the participants, which has been identified as beneficial to educational outcomes (Issenberg et al., 2005).

Does simulation allow the use of multiple learning strategies? Faculty felt that simulations allow for the use of multiple learning strategies. Though faculty responses were split on whether simulations allowed large groups of six or more participants to learn effectively, and also split on whether simulations were structured to allow for independent learning without an instructor, there was agreement on other key variables. Faculty agreed (81%) that simulations allowed every learner to have a hands-on experience, while all of the faculty (100%) agreed that simulations were structured to allow small groups of between two and five people to participate.

Faculty also agreed that simulations offered participants the ability to work in groups, have time to work things through, experiment with new ideas, and rely on others for information.

Do simulations allow the participants opportunities for repetitive practice? Repetitive practice is also identified in the literature as necessary to improve educational outcomes (Issenberg et al., 2005). There were several interesting findings on whether faculty felt participants had the opportunity for repetitive practice. Faculty were split on whether participants were offered the opportunity to practice skills before and after simulations, and to practice using the medical simulation devices after the simulation. However, most of the faculty (82%) indicated that participants were given the opportunity to practice using the medical devices before the simulation less than half the time. A large number of faculty (72%) said they only have time to facilitate repetitive practice about half the time.

Research Question 2

To what degree are high-fidelity simulations perceived as replicating real-world clinical scenarios?

Degree of fidelity and technical issues. When considering whether simulation scenarios had a high degree of accuracy in representing the physical and mental aspects of real-world scenarios, the faculty were indecisive. However, the majority of faculty agreed that a lack of visual and physical features in simulations detracted from the learners' experience. Most faculty (82%) had experienced technical issues with high-fidelity scenarios citing a variety of reasons, such as a manikin overheating, audio not working, the manikin becoming unplugged and a resultant loss of data, the lack of pressurization in simulation blood tubing, and a complete shutdown of the equipment mid-scenario. Tables 2.5 and 2.6 show the descriptive statistics of faculty responses regarding lack of visual and physical features in simulations.

Table 2.4

The Lack of Visual Features in High Fidelity Simulators Detract from the Learner's Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Somewhat Disagree	2	15.4	18.2	18.2
	Neither Agree nor Disagree	3	23.1	27.3	45.5
	Somewhat Agree	6	46.2	54.5	100.0
	Total	11	84.6	100.0	
Missing	System	2	15.4		
Total		13	100.0		

Table 2.5

The Lack of Physical Features in High Fidelity Simulators Detract from the Learner's Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neither Agree nor Disagree	5	38.5	45.5	45.5

Table 2.5 (continued)

	Somewhat Agree	6	46.2	54.5	100.0
	Total	11	84.6	100.0	
Missing	System	2	15.4		
Total		13	100.0		

Research Question 3

What is the cost of implementing simulations within the research context?

Associated costs of simulation lab operations. An exploration of the costs associated with running a simulation lab at UNMC shows that equipping and staffing a simulation lab requires a considerable amount of money. The majority of the operating budget is spent on personnel, while 15% of the total budgetary expense is spent on operating expenses such as warranties, supplies, and travel. The cost of equipment was not included in the 2017 fiscal year budget because the equipment had been purchased in prior years. Table 2.7 shows the itemized budgetary expenses for the 2017 fiscal year.

Table 2.6

UNMC Sorrell Clinical Skills Lab Budget for 2017 Fiscal Year

Category	Item	FY 2017 Budget
Personnel		
	Assistant Dean for Clinical Skills	61,384
	Manager, Advanced Simulation Operations	80,000
	Manager, Curricular Design	80,642

Table 2.6 (continued)

	Standardized Patient Program Coordinator	45,000
	Advanced Simulation Associate	55,000
	Program Manager	42,500
	Standardized Simulated Patients	84,000
	IT Support (Simulation Capture System)	20,000
	Total personnel cost	468,526
	Benefits	121,817
	Total personnel and Benefit cost	590,343
Operating Expense		
	Software/Warranties	50,000
	Operating	20,000
	Supplies	30,000
	Travel	8,000
	Total operation expenses	108,000
	Total Budgetary Expense	698,343

Discussion

Data from the faculty surveys revealed some important results related to the problem of practice. A surprising finding was that just under half of faculty (45%) indicated that they did not regularly use video or recorded data to support analysis of the student's performance in the simulation scenarios, which is surprising since video recording for use in feedback debriefing enhances learning outcomes (Lyons, et al., 2015). Another interesting finding was that faculty felt they did not have enough time to facilitate the repetitive practice of the participants. Faculty also felt that they rarely provided participants the opportunity to practice with medical devices before the simulations. This is a barrier to successful SBME implementation, as the literature shows that not being able to practice with the equipment before the simulations can increase extraneous cognitive load and lead to decreased learning outcomes (Fraser, Ayres, & Sweller, 2015). Data also show that most faculty experienced technical issues with the simulation which is consistent with the literature and identified as a main barrier to successful implementation (Dieckmann, Friis, Lippert, & Østergaard, 2012). Finally, the finding that 58% of faculty had never had a continuing education course in SBME is consistent with literature that indicates untrained faculty as a major barrier (Eppich et al., 2013; Stefanidis et al., 2015; Vyas, Bray, & Wilson, 2013).

Future plans will compare and contrast the data from the faculty and student surveys so that any commonalities can be identified. This data will then be used to explore a possible intervention. The next steps are to meet with the leadership at the simulation lab and discuss with them the findings. It is important to get the leadership's feedback because they will be able to determine the availability of resources for moving forward with an intervention.

Chapter 3 – Intervention Literature Review

SBME is a safe and effective teaching method that can bridge the gap between the classroom and the clinical environment. However, it has not been implemented into the curriculum in all medical schools and teaching hospitals (Huang et al., 2012). Barriers to SBME include: a lack of a pedagogical model that uses theory and evidence-based best practices (Kelly et al., 2016), the time commitment required by faculty and students (Eppich et al., 2013), confusion over fidelity (Tun et al., 2015) and the cost of implementation (Chinnugounder et al., 2015; Eppich et al., 2013). SBME is not fully integrated in the simulation lab at UNMC. Though UNMC has a functioning simulation lab, issues of equity, management, successful pedagogical models, and operational costs affect the ability to provide SBME access to all medical learners.

A needs assessment conducted in the simulation lab at UNMC found that faculty and students both felt they did not have enough time to facilitate and participate in repetitive practice of clinical skills (Miller, 2017). Faculty also felt that they rarely provided participants the opportunity to practice with medical devices before the simulations because there was not enough time scheduled in the simulation lab to allow for repetition of scenarios. This lack of student access is a barrier to successful SBME implementation, as the literature shows that not being able to practice with the equipment before the simulations can increase extraneous cognitive load and lead to decreased learning outcomes (Fraser, Ayres, & Sweller, 2015). The high cost of running a simulation lab was also found to be a factor, with most of the operating budget spent on personnel. Finally, students reported that a lack of realistic features of simulation manikins detracted from the learning experience (Miller, 2017).

Experiential Learning as a Theoretical Framework

This literature review and the intervention are informed by Kolb's (1984) experiential learning theory. According to Kolb, learning is "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (1984, p. 41). Experiential learning in Kolb's theory is comprised of four phases including (a) concrete experiences; (b) reflective observation; (c) abstract conceptualization; and (d) active experimentation (see Figure 3.1). Thus, the literature

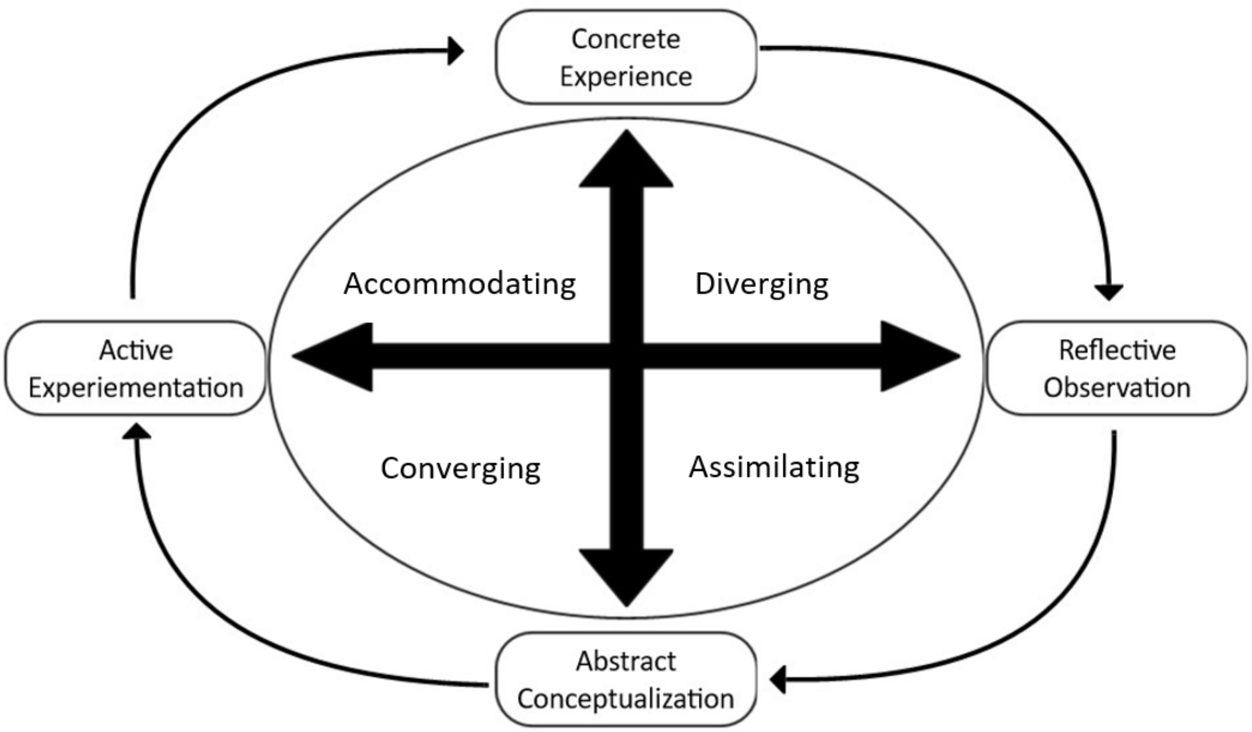

Figure 3.1. Kolb's experiential learning cycle. Adapted with permission from *Experiential Learning: Experience as the Source of Learning and Development* (p. 68), by D. A. Kolb, 2015, Upper Saddle River, NJ: Pearson Education, Inc. Copyright 2015 by Pearson Education, Inc.

review will be organized by these elements. Kolb's model also emphasized different learning modalities depending on where the learner is located in the experiential cycle, for example whether they are accommodating, diverging, assimilating or converging as they interact with the material (see Table 3).

Table 3

Characteristics of the Basic Learning Styles

Learning Modality	**Learner State**
Diverging	Learns from concrete experience and reflective observation.
Assimilating	Learns from abstract conceptualization and reflective observation.
Converging	Learns from abstract conceptualization and active experimentation.
Accommodating	Learns from concrete experience and active experimentation.

Note. Adapted from *Experiential Learning: Experience as the Source of Learning and Development* (p. 114-115), by D. A. Kolb, 2015, Upper Saddle River, NJ: Pearson Education, Inc. Copyright 2015 by Pearson Education, Inc.

These learning modalities map onto Kolb's four phases of experiential learning, and although learners should move through all four phases for optimal learning to occur, they may show preference for a certain phase based on individual learning styles (Kolb, 1984). The literature review will examine research of virtual reality use in education through the lens of this experiential learning framework.

Literature Review

The idea for the intervention is that immersive virtual reality (IVR) can be used to place medical students in a virtual clinical scenario where they can experience and practice the care and management of a virtual patient. This has the potential to provide students with pedagogical benefits including repetitive practice, provide a level of realism that cannot be replicated by manikins in a simulation lab, and offer schools a less expensive way to educate students. This literature review looks at research on IVR and similar virtual technologies with respect to mitigating cost issues and scheduling conflicts, increasing opportunities for repetitive practice, and providing realistic exposure to educational scenarios. Specifically, it will include VR and IVR in educational contexts, examining studies on presence, engagement, outcomes, and repetitive practice. The review will also include the use of gaming in medical education contexts as they are often a part of virtual environments. Finally, the literature review will look at the cost of implementation because this was a defined barrier to SBME access in the needs assessment.

Presence

Virtual reality creates a realistic depiction of an artificial environment, whereas IVR adds the additional concept of immersion to the virtual world, which emphasizes the user's sense of presence in a virtual environment with special attention to realism (Andreano et al., 2009). This attention to realism helps provide the learner with an improved learning experience. Such an experience can be facilitated by virtual reality and IVR. Persons that are exposed to virtual environments sense that they have a strong sense of presence in that environment (Hoffman et al., 2014). This sense of presence factors in to a successful concrete experience. Students that were tasked with communicating and collaborating with peers in a virtual environment called Second Life found that it facilitated their experiential learning (Jarmon, Traphagan, Mayrath, &

Trivedi, 2009). Their “sense of embodiment in SL [Second Life] helped to make their experiences in the virtual environment real and fostered their sense of concrete experiences” (Jarmon, Traphagan, Mayrath, & Trivedi, 2009, p. 179).

The Second Life virtual world has also been used to research presence in medical education, which includes learning medical material as in the case of nursing students. A study by Wiecha, Heyden, Sternthal, and Merialdi (2010) placed physicians in the Second Life virtual world for continuing medical education on type 2 diabetes. Participants gathered in a virtual classroom setting to learn about type 2 diabetes management and techniques and use the virtual chat function to ask questions and discuss scenarios with colleagues. The study found that physicians experienced enhanced educational outcomes that were beyond that of face-to-face or online professional development programs. This effect is partly attributed to the technology’s ability to create any scenario imaginable with an endless variety of virtual persons. A review of the use of virtual patients in medical curricula by Cendan and Lok (2012) found that providing students with such variety was a significant benefit of using virtual technology in medical education.

IVR is a nascent technology and has not been extensively researched in medical education. An early study by Stansfield, Shawver, Sobel, Prasad, and Tapia (2000) used nascent IVR technology to train first-responders to assess acts of bio-terrorism. The authors used an IVR system to place first-responders in a virtual environment where they had to assess and treat virtual patients. The authors found that the experience was concrete enough for the users to be satisfied with IVR as a training modality, but that the technology was not powerful enough to replicate the experience in a way that could optimize their training.

Users of IVR have emotional responses to the environment that are similar to responses in the real world. An experimental study that manipulated a user's height in IVR found that users' experienced feelings of paranoia and a reduction in social status when their height was lowered in social situations (Freeman et al., 2014). This reflection on feelings can apply to medical students by having them reflect on their emotions and feelings after being exposed to various medical scenarios.

A study by Deladisma et al., (2007) exposed medical learners to virtual patients that were experiencing abdominal discomfort. The researchers tracked the medical learners' eye movements and recorded their interactions with the virtual patients in order to understand the learners' emotional responses to the virtual patients' pain. The study asked learners to reflect on their encounter with the virtual patients and found that medical learners responded empathetically to the virtual patients. This is important because having empathy in medicine leads to better health outcomes and may have mitigating effects on physician burnout (Decety & Fotopoulou, 2015; Gleichgerrcht, & Decety, 2013).

Another study examined the behaviors of autistic children and found that their social interactions and behaviors improved significantly overtime in a controlled IVR environment compared to a desktop program with the same material (Lorenzo, Lledo, Pomares, & Roig, 2016). This can apply to medical learners that need to practice the regulation of emotional behaviors when exposed to traumatic events, and help them cope when encountering real-world medical scenarios. In a study that sought to understand people's reactions to high-stress environments, researchers showed that participants in an IVR simulation of an emergency evacuation reacted with emotional and social responses that were similar to reactions in real-world evacuations (Moussaïd et al., 2016). Taking time to reflect on these emotions after the IVR training can help learners process the experience (Kolb, 1984).

Experiential learning is predicated on an individual's interaction with their environment (Kolb, 1984). This sense of presence in the real-world scenario is an important feature of IVR environments (Lorenz et al., 2015). Studies exist that explore a sense of presence in medical IVR environments for both patients and learners.

Gokeler et al. (2016) used IVR to see if ACL reconstruction patients would alter their movement when exposed to a virtual environment post-surgery. The authors studied 20 athletes who were tasked with performing a step-down motion in both non-virtual and virtual environments. The authors concluded that a realistic virtual environment was persuasive enough to override the patients' motor control so that their movements were similar to those of healthy control subjects, paving the way for IVR use in rehabilitation programs (Gokeler et al., 2016). This sense of presence in the virtual world is important to active experimentation and has been replicated in other studies.

A 2015 study by Heydarian et al. used a controlled pilot experiment gauge how participants perform everyday tasks in an IVR environment compared to a real physical environment. An independent sample *t*-test found that there was no difference in all the parameters examined between the participants' interactions in the virtual environment compared to the physical environment. The conclusion is that an IVR environment can sufficiently replicate the real world in such a way that the participants have a strong sense of presence (Heydarian et al., 2015). The implication is that active experimentation can take place in a virtual environment as if it were an actual physical environment but with the added benefit of manipulating the environment to suit the learners' needs and encourage active participation. This sense of presence is especially powerful when the user experiences body ownership in the virtual environment.

A study by Kilteni, Bergstrom, and Slater (2013) immersed participants in a virtual environment to expose them to drumming patterns. Their hands were represented by virtual hands alongside a virtual player that accompanied them as they played a drum. Participants that had a greater sense of body ownership (participants who felt that their hands in the virtual world belonged to them) showed greater improvements in their drumming patterns. The authors conclude that body ownership can result in behavioral changes, and that a virtual body that is different from their own is readily adopted if it is more appropriate for a specific task (Kilteni, Bergstrom, & Slater, 2013). This sense of body ownership can also apply to non-verbal communication in virtual environments. The presence that users experience is also closely linked to engagement. It is through a sense of presence that users in virtual reality experiences can find increased motivation to interact with the virtual world.

Engagement

Virtual reality experiences can also be designed to help motivate students and facilitate the exploration of creativity as well as aid in knowledge retention. When students were exposed to an educational virtual reality environment, a multimodal analysis of communication, interactivity, and student perceptions showed that students had fun, felt free to explore new ideas, and came up with creative solutions to problems (Lau & Lee, 2015).

Students using virtual reality technology have also had positive experiences. When students used virtual reality to learn about anatomical structures in medical education, considerations of imagination and immersion in the design of the virtual environment was positively correlated with perceived usefulness and ease of use (Huang, Liaw, & Lai, 2016). In another study, medical students working with virtual, computer-generated patients felt increased confidence in clinical reasoning skills and the authors developed a tool to effectively measure student satisfaction when working with virtual patients, a resource that will be valuable for future research (Sobocan & Klemenc-Ketis, 2016; Sobocan & Klemenc-Ketis, 2017). The increase engagement predicates that users of VR and IVR in educational settings may benefit from the experience in a way that has a positive affect on their educational outcomes.

Educational Outcomes

Some of the most promising uses for VR have been researched in surgical training. One study found that residents who trained with VR for laparoscopic surgery were less likely to make errors, whereas the control group had three times as many errors and their surgery time was 58% longer (Ahlberg et al., 2007). Despite the shorter time in surgery, the quality of training is also greater. Another study by Larsen et al. (2009) found that learners who used laparoscopic VR trainers, score points equivalent to 20-50 procedures, where the control group scored points that were equivalent to only five procedures. Another study found that even surgical novices can improve their technical skills when training on VR trainers with deliberate practice (Palter & Grantcharov, 2014).

The IVR technology has evolved significantly since the Stansfield et al. (2000) study, however there are few studies that explore how IVR is being used in medical education utilizing new hardware and software capabilities. The research that is available provides some insights into how this improved technology affects educational outcomes. One such study used a camera to capture stereoscopic renderings of a human brain that were then rendered into a virtual reality program. The authors found that students significantly improved their knowledge of anatomical structures in a posttest compared to traditional teaching methods (de Faria, Teixeira, de Moura

Sousa Júnior, Otoch, & Figueiredo, 2016). A systematic review that examined the use of educational technology in education found that virtual and simulated patients led to more authentic learning experiences and improved educational outcomes when combined with problem-based learning (Jin & Bridges, 2014).

A meta-analysis also found that virtual reality was an effective means of instruction that increased knowledge retention in students beyond short-term memory (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). Another study that used an IVR framework showed that students manipulating virtual blocks could change their cognitive abilities during their immersive experience with significantly higher improvement than in a tangible, 2D environment (Passig, Tzuriel, Eshel-Kedmi, 2016).

Medical learners that take advantage of virtual reality experiences as part of their medical education can increase their knowledge of concepts. A study by Fernandes, Elli, and Giulianotti, (2014) discuss how virtual reality training in robotic surgery is a powerful teaching tool that can contribute to a surgeon's conceptualization of the surgical environment. Another study by Sweigart et al., (2016) examined how a virtual reality environment affected nursing students' attitudes toward teamwork. The authors found that the nurses' virtual experience helped them significantly change their attitudes toward leadership and communication, signifying that they were able to conceptualize teamwork in a new way after the reflective observation of their participation.

A recent study by Orman, Price, and Russell (2017) used IVR with augmented reality to enhance the non-verbal communication of novice music conductors. Participants were placed in a virtual environment where their head movement, eye movement, and torso movement could all be tracked. The virtual world was manipulated in such a way that the conductor was provided with indicators of where in the ensemble they should focus their attention during various parts of the musical score. When the data was analyzed by professional conductors, it was determined that the IVR participants had gain scores of body movement that were much higher than the control group that conducted using traditional methods (Orman, Price, & Russell, 2017). The implication is that using IVR with environmental manipulation can increase non-verbal communication skills, which is also an important component in medical training. Along with increases in educational outcomes, VR and IVR provide the learner with the ability for repetitive practice because they can enter the virtual environment at their convenience.

Repetitive Practice

In reflective observation, the users reflect on their learning experience by taking a step back from the experience and reviewing what they have done (Kolb, 1984). This reflection is important to assimilate the educational experience as well as process the emotional component of the experience. Virtual reality in medical education has a variety of applications that can enhance learning (Pelargos et al., 2017). The technology has provided a way for neurosurgeons to create a 3D model of a real patient's anatomy and then render that imaging in a virtual environment to practice pre-surgical techniques and approaches (Ferroli et al., 2013). This provides surgeons with the ability to have a concrete experience of practicing a surgical procedure without the risk of harming a real patient.

In a review of virtual simulators for endoscopic surgeons, Carter et al., (2005) emphasizes that virtual reality surgical simulators allow for the surgeon's reflective observation of their performance. This ability to practice skills, is an important feature of VR technology. A study by Burden et al., (2013) recruited 18 obstetric ultrasound trainees to participate in a virtual reality simulation in order to assess if such a modality is feasible. As the trainees were able to repetitively practice their techniques, their skills improved to near-expert levels. By using the virtual reality trainer "the trainee is given the opportunity to make reflective observations from the feedback provided by the simulator, enabling them to hone skills based on their own experience" (Burden et al., 2013, p. 217).

Another study by Salminen, Zary, Björklund, Toth-Pal, and Leanderson (2014), used virtual patients to further explore how their use contributes to reflective practice. The authors used Kolb's (1984) experiential learning cycles as a framework and found that students accepted the teaching modality and found that it facilitated their ability to reflect upon their clinical performance (Salminen, Zary, Björklund, Toth-Pal, & Leanderson, 2014).

Learners' reflections on their perceptions and attitudes toward IVR use help solidify the concrete experience. These studies suggest that IVR has the potential to replicate the real world in ways that illicit comparable responses in users. The benefit is that real-world situations can be presented in safe and relatively inexpensive ways. Once the learner has had the opportunity to reflect upon their learning experience, they then are able to compare this new experience with what they already know and arrive at a new understanding (Kolb, 1984). This next section will examine how gaming plays a role in virtual environments.

Gaming

The phase of abstract conceptualization can also be facilitated through gaming, where Kolb's (1984) experiential learning theory is used as a model to link gaming with pedagogy (Kiili, 2005). Serious games, games used for educational purposes, help learners gain new understanding through learning from an abstract conceptual phase of the experiential learning cycle as well as providing learner analytics in real time (De Gloria, Bellotti, Berta, & Lavagnino, 2014). In these games, learning takes place seamlessly, where the games' objectives are matched to the learning objectives and playing through the game results in knowledge and skills acquisition (Graafland, Schraagen, & Schijven, 2012). Games and virtual reality are complementary because they both provide an immersive experience for the learner (Ferguson, Davidson, Scott, Jackson, & Hickman, 2015). Using games in this way has benefited medical education.

A study by Nevin et al. (2014) used a web-based game to test the medical knowledge of internal residents in a competition format. The study uses a mixed-methods design that gathered and analyzed data through focus groups and software metrics. The authors found that the use of gamification, which is adding game elements to educational curriculum, was enjoyable for the learners and can be a successful supplement to medical instruction within time-constrained environments (Nevin et al., 2014). This last point is especially critical since a needs assessment found that learners do not have time to facilitate repetitive practice of their skills (Miller, 2017).

This type of competitive gamification has also been used in medical simulation training. In a 2014 study on the use of gamification elements to facilitate the acquisition of surgical skills, Kerfoot and Kissane (2014) devised a single-elimination tournament with a leaderboard and monetary prizes. The authors found that adding gaming elements into the medical simulation significantly increased the use of the simulator which reduced the cost per hour of the simulator. Use of a surgical simulator is also correlated with an increase in satisfactory surgical skills (Khunger & Kathuria, 2016). Thus, gamification can provide multiple benefits for medical education learners and facilitators. Of course, for gamification to maximize its potential in educational systems, the learners need to accept it as a viable component of instruction.

Malhotra, Kabra, and Malhorta (2017), examined the attitudes and practices of medical students concerning video games. The study looked at video game usage in a sample of 225 medical students. The authors found that while 95% of students played video games, only 23% had played them to supplement learning. However, 95% of the students thought that using serious games to supplement their learning would be welcomed. This gap between actual use and willingness to use will close as educational games are adopted into the medical curriculum. Once the learner has engaged in abstract conceptualization and has understood the delivery of new material, they are ready to move on in Kolb's (1984) learning cycle to active experimentation.

In developing 3D simulation games for education, Galvão, Martins, and Gomes (2000) explain that players are involved in "active experimentation of the learning p

rocess, because they test different implications of concepts in new situations in a real-life context" (p. 1693). A study by Le, Pedro, and Park (2015) used this concept to create a serios game for educating construction workers on health and safety. The authors found that a social and collaborative virtual reality game has the ability to improve safety and health education. Similarly, Sabri et al., (2010) used Kolb's (1984) experiential learning theory to design a game that helps train orthopedic surgeons to perform total knee replacement surgery. The authors designed the game specifically to facilitate active experimentation.

In another study by Sung, Hwang, Lin, and Hong, (2017) Kolb's (1984) experiential learning cycle framed research that examined the effects of game-based learning on student motivation. The authors found that when students were able to actively experiment in the game by going on new adventures and applying what they learned to new scenarios, they had a significant increase in learning motivation. The benefits of game-based learning can also be seen with virtual reality applications in medical education.

A study by Koivisto, Niemi, Multisilta, & Eriksson, (2017) used experiential learning with an emphasis on active experimentation to investigate nursing students' perspectives on how they learn while playing an online 3D simulation game. The researchers used a collaborative approach to design a game that presented learners with various patient scenarios. These scenarios were constructed to develop clinical critical thinking skills. Results show that students experimented by exploring decision making and that the game has the potential to teach critical thinking skills as long as the game can accurately represent a clinical environment. This replication of real-world environments is where IVR has an advantage.

When comparing the difference between traditional gaming experiences and gaming in IVR, Pallavicini et al., (2017) used a first-person game played on a tablet and in IVR to study players' experiences using these different gaming modalities. The authors found that even though IVR players have greater anxiety when playing the game, they found that the IVR version was more appealing. This suggests that appealing effects of serious games are enhanced when designed and played in an IVR environment.

`A rigorous experimental design by Verkuyl, Romaniuk, Atack, and Mastrilli, (2017) used active experimentation to study the effects of a virtual game-based simulation on nursing students' pediatric knowledge, self-efficacy, and satisfaction. The researchers found that those who participated in the experimental group had statistically significant greater gains in self-efficacy than the control group. The authors suggest that "stronger gains were made by the [virtual gaming simulation] VGS group because the game is played individually. Kolb's theory supports the premise that learning is most effective when learners are engaged in active experimentation" (Verkuyl, Romaniuk, Atack, & Mastrilli, 2017, p. 242).

As discussed previously, with the sense of presence, body ownership, and movement, there is an underlying question of which user would most benefit from virtual experiences. Is there a certain typology of participant that would derive more from the IVR experience than others? A study by Rosa, Morais, Gamito, Oliveira, and Saraiva (2016) sought to answer this questions by profiling different users of IVR technology to determine which persons are more suitable for IVR interventions. After examining IVR use among 71 undergraduate students, the authors determined that PC gamers were more likely to experience the positive effects of IVR, due to their familiarity with immersion in virtual worlds. Non-gamers and older individuals were more likely to have negative experiences, mainly due to experiencing cybersickness (Rosa, Morais, Gamito, Oliveira, & Saraiva, 2016). However, cybersickness is less as a factor, as IVR technology has evolved to mitigate latency issues, which previously caused individuals to experience symptoms of motion sickness when using IVR (Lincoln et al., 2016). As the technological power of IVR increases, the cost of the equipment also begins to decline, making the technology more affordable for application.

Cost

Earlier studies researching virtual reality applications used costly equipment that limited accessibility, however new technology has made virtual reality more affordable (Dascal et al., 2017). One of the main reasons for the decrease in cost, is that the gaming industry has ushered in a new era of virtual reality for the average consumer to use at home (Standen et al., 2015). Lower costs have also allowed clinicians to use virtual reality technology in their offices to treat medical conditions such as developmental delays in children (Salem, Gropack, Coffin, & Godwin, 2012).

An exploratory demonstration by Mathur (2015) showed that educators can design a low-cost virtual reality setup using the Oculus Rift and Razor Hydra to provide medical learners with an IVR experience designed to teach the identification of organs and the performance of incisions. Such a low-cost design can take advantage of the experiential learning benefits that IVR affords.

A recent analysis by Buń et al., (2017) on low-cost IVR equipment for educational applications provides examples of IVR equipment that is commercially available and affordable for use. The analysis covers head-mounted displays, computers, haptic equipment, and body-tracking systems. The authors conclude that it is possible to provide how-cost IVR equipment for educational purposes, with the caveat that the most expensive hurdle is in software production and creation. This analysis will serve as an important paper to reference when designing an IVR intervention for the problem of practice.

Though there is a consensus in the literature that IVR technology is becoming increasing affordable and is significantly less expensive than current medical simulation technology (McGrath et al., 2018), there are few research studies that explore the cost-benefit of IVR use compared to traditional medical simulations. The research that explores the cost-benefit of using virtual reality is mostly limited to studies on patients rather than on medical learners, however the studies still provide insight on how IVR technology can provide a lower cost alternative to traditional methods of clinical procedures.

A study by Lloréns, Noé, Colomer, & Alcañiz, (2015) studied the cost-benefit of a virtual reality rehabilitation program designed to help stroke victims recover balance. The researches designed a VR platform that could be used in the patient's home and compared this treatment to traditional therapy at the rehabilitation clinic. While both groups saw significant improvements in balance, there was no difference in usability ratings. However, the VR program at the patient's home had a greater cost-benefit than the program at the clinic.

The Oculus Rift, an IVR technology originally designed for gaming is now being used in analgesic studies and is one thousand times less the cost of technology used in previous studies (Hoffman et al., 2014). The equipment is so inexpensive compared to traditional medical practices that even developing countries can use virtual reality to help patients (Morris, Louw, & Crous, 2010). Given that the high cost of simulation labs is a barrier to adoption (Chinnugounder et al., 2015) it is conceivable that IVR can help supplement or even replace traditional SBME modalities.

Conclusion

Immersive virtual reality in its current form is a very nascent technology. Thus, there is very limited literature that supports its use, especially in medical education. The dearth of literature indicates the need to further examine literature that uses virtual technology and games in medical education, and the broad application of virtual reality in education. Understanding how this technology has been used and measured, when applied to Kolb's (1984) experiential learning theory is an important foundation for the intervention. By applying the experiential learning framework to the use of IVR in medical education, the reasons for its effectiveness and continued use become apparent. With the further consideration of how gaming elements can apply to the educational experience, the inclusion of such elements in an IVR environment serve to further enhance its pedagogical value. The technology required is increasingly affordable and is currently available for commercial use, which aids in dissemination and adoption by educators and medical facilities. As the technology continues to evolve it will become more immersive, less expensive, and increasingly mobile. The implications for its future use in medical education deserve further research and study.

Chapter 4 – Intervention Procedure and Program Evaluation Methodology

Introduction

Immersive virtual reality is a nascent technology that is beginning to find its way into education and the research literature. The advent of new technologies has made it possible to immerse learners in virtual environments that can be manipulated to provide students with countless educational experiences and scenarios (Farra, Smith, & Ulrich, 2018; Freina, & Ott, 2015). Medical education has taken advantage of virtual reality technology but is just now starting to use immersive virtual reality as an educational tool (Padilha, Machado, Ribeiro, & Ramos, 2018; Kilmon, Brown, Ghosh, & Mikitiuk, 2010). Using Kolb's (1984) experiential learning theory as a framework where learning is comprised of four phases including (a) concrete experiences; (b) reflective observation; (c) abstract conceptualization; and (d) active experimentation, the literature review looked at research on IVR and similar virtual technologies with respect to mitigating cost issues and scheduling conflicts, increasing opportunities for repetitive practice, and providing realistic exposure to educational scenarios. Virtual reality creates a realistic depiction of an artificial environment, whereas IVR adds the additional concept of immersion to the virtual world, which emphasizes the user's sense of presence in a virtual environment with special attention to realism (Andreano et al., 2009; Bertrand, Guegan, Robieux, McCall, & Zenasni, 2018; Slater, & Sanchez-Vives, 2016). This attention to realism helps provide the learner with an enhanced learning experience that can help mitigate issues of access, repetitive practice, and cost that were discussed in the needs assessment. This chapter outlines the intervention procedure and program evaluation methodology using a mixed-methods approach to implementing IVR in a medical training scenario for supraventricular tachycardia (SVT) patient assessment skills. Originally, the researcher intended to focus on stroke patient assessment skills as the educational content of the intervention. However, the educational content changed to supraventricular tachycardia (SVT) patient assessment skills. The reason for this change was the availability of qualified faculty to create the simulation scenario. After discussions with qualified nurse practitioners and simulation specialists, it was determined that an SVT scenario would be more conducive to clinical judgement assessment as well as a compatible scenario for programming the mannikin. This change in curriculum content did not affect any other aspects of the study, and the same methodology, data gathering, and data analysis were used in the study.

Research Design and Logic Model

The purpose of the study was to ascertain whether IVR can be used to place medical learners in a virtual clinical scenario where they can experience and practice the care and management of a virtual patient. This would provide students with pedagogical benefits including repetitive practice, provide a level of realism beyond what can be replicated by manikins in a simulation lab, and offer schools a less expensive way to educate students.

Logic Model

The proposed intervention explored the use of IVR to teach senior-level nursing students Supraventricular Tachycardia (SVT) assessment skills with the intended purpose that successful outcomes would afford them opportunities for repetitive practice. The details of the intervention were presented through a narrative and illustrated using a logic model (see Figure 4.1). The items covered in the following narrative are the inputs, activities, outputs, outcomes, assumptions, and external factors.

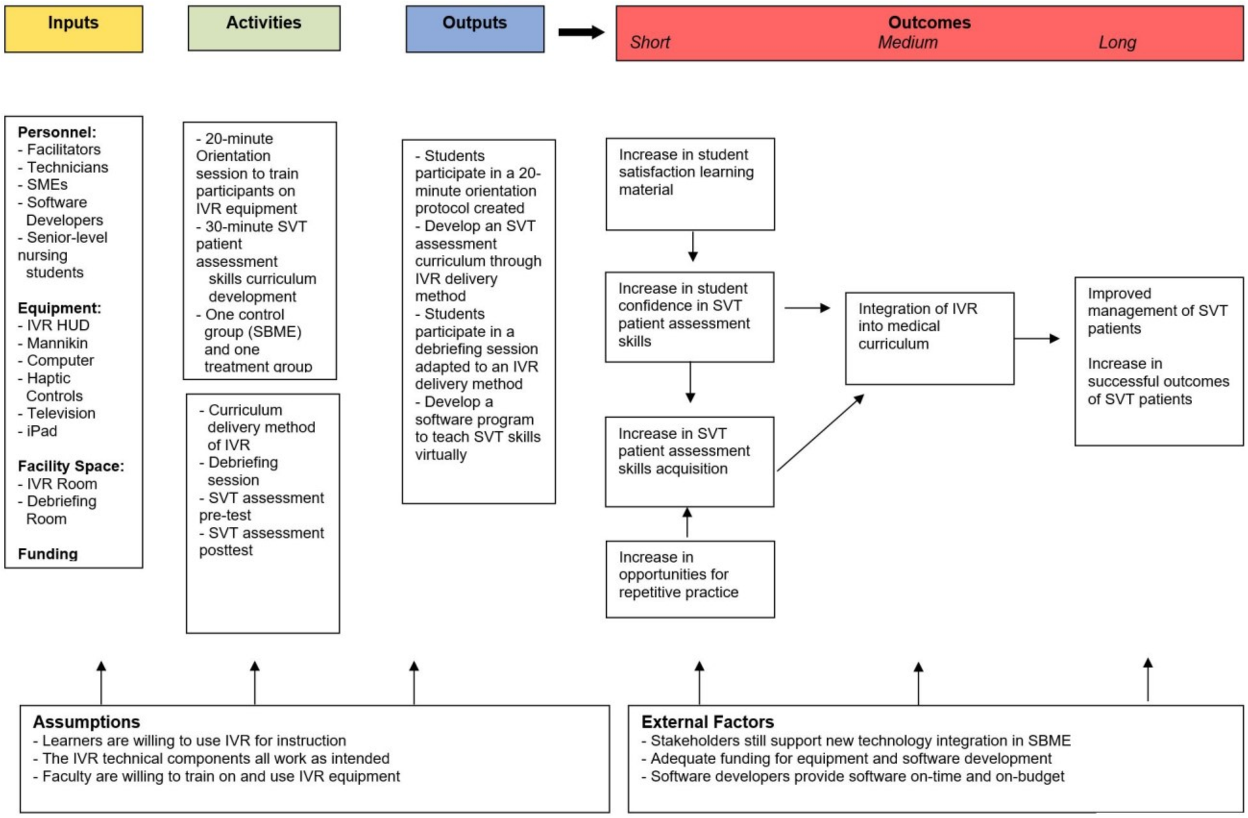

Figure 4.1. A logic model for an SVT skills acquisition intervention using an IVR delivery method.

Inputs. The inputs for the intervention were the resources and infrastructure that were needed to support the project. In this intervention the resources consisted of personnel, equipment, facility space, and funding. The personnel necessary for a successful intervention required a variety of highly qualified individuals (see Figure 4.1). Facilitators needed to be present. This consisted of experienced faculty who observed the simulation, evaluated learner performance, and conducted debriefing sessions. This supervision was necessary during initial training as studies have shown that supervision during medical scenarios increases educational outcomes (Farnan et al., 2012). Qualified personnel also included technicians that aided in the technical setup of all the equipment. Software developers were also needed to provide the platform that the researcher used in creating the IVR program, and the researcher worked closely with subject matter experts to ensure that the translation of the curriculum to an IVR environment met existing learning outcomes. Finally, senior nursing students were selected because they have the requisite knowledge, have not yet been exposed to a SVT assessment curriculum, and have not yet had much experiential training (Promes et al., 2009). In addition to personnel, the intervention also required equipment.

The equipment needed for the intervention was the instructional media and supporting devices. The instructional IVR media consisted of an Oculus Rift head-mounted display which displays video in an immersive 360° format and tracks head movement, software, and a haptic controller to immerse learners in the virtual clinical scenario. An iPad and television were used to broadcast the IVR content that the student was experiencing inside the Oculus Rift. This was so that the facilitators could assess student performance. Additionally, supporting devices were needed for the traditional SBME control group. These included a computer to run the simulation, a mannikin that served as the SVT patient, and a television monitor that provided the students with the simulated patient's vitals. The personnel and equipment all needed adequate facility space for the intervention.

The instruction took place within Midland University's simulation lab at Methodist Fremont Health Hospital and a designated office space on Midland University's campus. One of the rooms was planned for IVR facilitation and it provided the adequate space for the equipment and the personnel to successfully carry out the intervention. The equipment and software used at the facility did not require funding to procure.

The intervention required funding in order to purchase several Oculus Rift IVR units, including the heads-up display, and haptic controls. The amount of money needed to develop the software from scratch proved to be cost-prohibitive, so the researcher developed a lower-budget IVR scenario for the experimental group. Before the intervention could be implemented, several activities were completed.

Activities. There were several necessary activities that needed to take place that were associated with the inputs from the logic model (see Figure 4.1). One of the first activities was to arrange and negotiate the facility space and schedule. The facility was in use at the time of the intervention, so arrangements had to be made with the facility manager as well as the resident director to coordinate and align schedules. Another important activity was gathering funding for the intervention. The funding was obtained through the researcher's personal funds. The money was used to purchase equipment and the software that was necessary for IVR content development and delivery.

The facilitators observing the educational scenario were trained on the IVR equipment, with special attention to the purpose and function of its use. This training was important since a lack of faculty training on simulation equipment is a major barrier to successful use (Okuda et al., 2009). Another activity was the development of the curriculum. Although a standard SVT assessment curriculum already exists, it was necessary to partner with subject matter experts in order to translate an existing curriculum to an IVR software program. This required close coordination with the software development as well as the formation of a small pilot group of initial nursing students to pilot test the equipment and the delivery method for iterative improvement. Therefore, once the equipment was procured, set up, and tested, there was a period of one week allocated for changes to be made with the facility space as well as any suggested changes from the pilot group. Once all of the activities were performed, the intervention was administered.

Outputs

The target population for the intervention was senior-level nursing students at Midland University and Nebraska Methodist College (N=40). They are at an educational level where they are expected to dramatically increase their knowledge and skills in clinical settings and are expected to know SVT assessment skills and patient management. Furthermore, SBME is an important part of intern training, as it helps bridge the gap from theory to applied practice and increase confidence when exposed to real patients and medical situations (Datta, Upadhyay, & Jaideep, 2012). The interns were split into two groups and randomized to a control group and a treatment group. Both groups were given an SVT assessment pretest to establish a baseline for their knowledge and skills. The treatment group was given SVT assessment skills instruction via an IVR delivery method, and the control group received traditional SVT assessment skills instruction through a traditional simulation lab training scenario.

Both groups were given approximately 30 minutes of SVT assessment skills instruction based on common events outlined in the standardized nursing curriculum. Although both groups received instruction in SVT assessment, the treatment group was immersed in a virtual reality scenario where they experienced a simulated SVT exhibiting cardiac symptoms indicative of SVT. Both groups had to perform the following component skills:

- Understand normal lab values and vital signs
- Examine patient chart and orders
- Compare the patient’s current status to the baseline status received in the report
- Identify nursing interventions for SVT
- Perform physical and psychosocial assessment
- Review patient chart for H&P, vitals, labs, test results, prior orders

- Measure vitals
- Provide physiologic monitoring (pulse ox, ECG, FHR monitoring)

The control group participated in a traditional SVT assessment using a manikin in the simulation lab. Following the instruction, both groups participated in a debriefing. Debriefing has been used in simulation-based medical education to assess student skills and experience, and is a proven method for assessing learners' knowledge (Cheng et al., 2016). Debriefing as an assessment tool allows faculty and students to understand the areas where they successfully performed and the areas where they need to improve. Using a debriefing model in assessment establishes a dialogue between the learner and the instructor and allows for a deeper understanding of acquired knowledge and learning deficits (Dreifuerst, 2012). Both groups were also assessed on their clinical judgement during the SVT scenario by trained observers using the Lasater Clinical Judgement Rubric (LCJR) (Lasater, 2007). The LCJR (see Appendix A) measures four dimensions of clinical judgement. These are (a) effective noticing, (b) effective interpreting, (c) effective responding, and (d) effective reflecting. These dimensions are measured by four levels on the rating scale. These four levels are (a) beginning, (b) developing, (c) accomplished, and (d) exemplary. Each criterion in the dimension is measured using this scale for a total of 11 criteria.

Thus, the intended products of the intervention were an SVT assessment curriculum plan administered through an IVR delivery method (see Figure 4.1), a debriefing session that analyzed learners' experience and skills acquisition, and a structured plan for an SVT assessment curriculum with IVR. This latter product was used to develop a curriculum that uses scaffolding so that learners can practice the scenario independently on their own time and at their preferred location. It was anticipated that the intervention will bring about changes in the target population.

Outcomes. One of the fundamental skills that medical learners need to master SVT assessment, which is the support and management of patients exhibiting SVT symptoms (Page et al., 2016). To support this mastery, there were four anticipated short-term outcomes for this intervention (see Figure 4.1). The first outcome is that learners in the treatment group would experience greater satisfaction learning the material through an IVR delivery method than the control group that learns through a traditional simulation lab scenario. Student perceptions of an educational virtual reality environment showed that learners had fun, felt free to explore new ideas, and came up with creative solutions to problems (Lau & Lee, 2015). The second outcome was that this satisfaction leads to an increase in learners' confidence of their SVT assessment skills. In another study, medical students working with virtual, computer-generated patients felt increased confidence in clinical reasoning skills (Sobocan & Klemenc-Ketis, 2016). The third outcome was that increased satisfaction and confidence would correlate to an increase in SVT assessment skills acquisition. A meta-analysis found that virtual reality was an effective means of instruction that increased knowledge retention in students beyond short-term memory (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). The fourth and final short-term outcome was that the IVR delivery method provides learners with the opportunity to practice their SVT assessment skills at a time and place that is convenient to their schedule, perhaps even at home. The reason is that IVR is a mobile technology and has now become affordable for home use (Standen et al., 2015). These anticipated outcomes will also lead to medium and long-term outcomes.

The medium range outcome is that the IVR delivery method will be integrated into the curriculum for students to practice multiple skills in other content areas. A needs assessment showed that students did not have enough access to simulation labs in order to practice their skills (Miller, 2017). Therefore, it is anticipated that if the short-term outcomes are achieved, learners will be given the opportunity for repetitive practice using the IVR delivery method at a place and time that is suitable to their schedules. Studies show that deliberate practice of skills learned in simulation leads to increased learning outcomes (Chee, 2014; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011). Therefore, it is anticipated that if learners are given the opportunity for repetitive practice using the IVR delivery method at a place and time that is suitable to their schedules, their SVT assessment management skills will continue to increase and the long-term impact is the improved management of SVT patients (see Figure 4.1). The improvement in patient management would also lead to an improvement in patient outcomes. The intervention process and subsequent outcomes operated on several assumptions and took into account several external factors.

Assumptions and external factors. The intervention assumed that the learners will be willing and able to use the IVR equipment for instructional delivery. This assumption was supported by two studies, where students (Huang, Liaw, & Lai, 2016) and patients using IVR for instructional delivery reported having a positive experience. Another assumption was that all technical aspects of the intervention will function correctly and as intended, and that any technical glitches could be quickly ameliorated. It was also assumed that faculty were willing to train on the new equipment and incorporate the delivery method into their curriculum. This assumption was supported by a study that showed that faculty who have a technical background and internal support systems are more likely to adopt new technologies (Reid, 2014), and since simulation faculty fit this category, they were more likely to adopt and integrate the IVR delivery method. Some external factors that were out of the researcher’s control were Midland University’s nursing department and Academic Affairs administrators’ support of new technologies, which is currently strong, and that the software development would provide the needed content on-time and remain on-budget.

Method

The intervention employed a mixed methods approach, embedded design that used qualitative data to support the primary quantitative results. Mixed methods research is designed to use quantitative and qualitative data collection and analysis in the methodology (Creswell & Plano Clark, 2011). The strengths of this method is in using a mix of quantitative and qualitative data because combining these methods makes up for the weaknesses of each. For research that has insufficient data or needs to be explained further, a mixed methods approach can provide a more wholistic picture of the phenomena under investigation because it utilizes quantitative and qualitative data within a single investigation(Wisdom & Creswell, 2013). Another strength of the mixed-method design for this research was that it allowed for a broader array of questions that use qualitative data to help explain quantitative results. This is exemplified in an embedded design where primary data, in this case the quantitative data are supported by the qualitative data (Wisdom & Creswell, 2013). Some weaknesses of this approach are that it can be difficult to implement by one researcher, which was the case in this study, and it can also be time-consuming which is problematic with a shortened timeline (Shadish, Cook, & Campbell, 2002). The shortened timeline for this study resulted from the need to accommodate the nursing students' schedules, and to situate the intervention so that the students' prerequisite knowledge allowed for their successful navigation of the simulation lab environment, but before their exposure to SVT curriculum.

The null hypotheses were that there would be no change in skills acquisition scores from pretest to posttest between the experimental and control groups as indicated by a paired-samples *t*-test and that there would be no increase in the satisfaction and confidence level of medical learners as indicated in a post-intervention survey and semi-structured interview. The intervention took place in the Midland University simulation lab at Methodist Fremont Health Hospital in Fremont, Nebraska and a room on Midland University's campus and was designed to answer the following process (PERQ) and outcomes (OERQ) evaluation research questions:

PERQ1	Did learners feel that a 20-minute orientation session with the IVR equipment was enough time for them to become familiar with its use for the subsequent instructional session?
PERQ2	To what degree did the implementation of the IVR instructional method align with the intended research design?
PERQ3	What was students' level of participation during the IVR instructional method?
OERQ1	A. What is the change in medical learners' clinical judgement skills after SVT assessment in an IVR instructional delivery method compared to medical learners using a traditional simulation lab instructional delivery method? B. What is the change in medical learners' SVT knowledge acquisition after SVT assessment in an IVR instructional delivery method compared to medical learners using a traditional simulation lab instructional delivery method?
OERQ2	What is the change in medical learners' confidence level in assessing a SVT after and IVR instructional delivery method?
OERQ3	What is the medical learners' perception of satisfaction with the instructional delivery method?

These questions are discussed later in the chapter and are broken down into both process evaluation and outcomes evaluation. The rest of this section will discuss participants, instrumentation, and procedure.

Participants

Participants were selected from a randomized convenience sample of senior-level nursing students at Midland University and Nebraska Methodist University. Inclusion criteria were that students had not had exposure to SVT assessment simulation scenarios in the curriculum. The 18 participants were randomized into a control group (n=9) and a treatment group (n=9). Prior to the start of the intervention, both groups took an SVT assessment skills pretest. Then, the treatment group participated in a 30-minute SVT assessment skills instruction delivery through IVR, followed by a debriefing session with an experienced faculty member. The control group participated in a traditional SVT assessment skills simulation lab scenario.

Informed consent was collected from all participants and was reviewed verbally prior to the intervention. During the intervention each participant in the treatment group used immersive IVR equipment to engage in an SVT assessment skills scenario that addressed specific competencies. After the scenario, participants participated in a 20-minute debriefing session. All debriefing sessions were conducted by an experienced faculty member that observed the SVT assessment skills scenario and all debriefing sessions were audiotaped. The faculty conducting the debriefing also experienced the SVT assessment skills scenario delivered through the IVR equipment.

Measures and Instrumentation

The proposed intervention used a mixed methods, embedded design. In an embedded design the primary data, which were quantitative, are supported by the secondary qualitative data

(Creswell & Plano Clark, 2011). Therefore, both quantitative and qualitative data were collected using a variety of measures (see Appendices A & B). What follows is an explanation of the measures and instrumentation that were used for each variable.

Variables. The variables in this mixed methods embedded design, were comprised of independent (IV), dependent (DV), moderating, and mediating variables. Each variable was operationalized through definitions in the literature and was indicated in the research design according to the following:

Table 4.1

Variables in a Mixed Methods Embedded Design Intervention

Variable	Operational Definition	Valid Indicator
Prior knowledge of simulation lab SVT assessment (Moderating)	Knowledge of objectives and skills required in a simulation scenario (Shilkofski, Nelson, & Hunt, 2008)	Results of a simulation scenario pretest
IVR as Delivery Method (IV)	Treatment group receives SVT assessment instruction using IVR	Indicated through instructional method employed
Traditional simulation as Delivery Method (IV)	Control group receives SVT assessment instruction using traditional simulation lab	Indicated through instructional method employed
SVT assessment Clinical judgement skills acquisition (DV)	Assessment of SVT clinical judgement skills after IVR intervention (Lasater, 2007)	SVT assessment skills posttest
Satisfaction and student self-confidence (DV)	The level to which students report satisfaction and self-confidence in their SVT assessment skills. (NLN, 2005)	Questionnaire tabulating student satisfaction and self-confidence

Table 4.1 (continued)

SVT knowledge acquisition posttest (DV)	Knowledge of objectives and skills required in a simulation scenario (Shilkofski, Nelson, & Hunt, 2008)	Results of a simulation scenario posttest
Semi-structured interview	Qualitative data helps to explain quantitative results (Creswell & Plano Clark, 2011)	Semi-structured interview to gather qualitative data about intervention experience

Demographics. Demographic information was collected for the population sample, which was comprised of senior-level nursing students at Midland University and Nebraska Methodist University. The data gathered consisted of basic demographic information such as gender, age, and school affiliation. These moderating variables were examined to determine their impact on the dependent variables in the study. The researcher gathered demographic data on the research subjects in order to determine if there were any gender effects, as the literature shows that gender has an effect on the examination results of medical learners (Haq, Higham, Morris, & Dacre, 2005). The instrument used to collect demographic data was the demographic section of an instrument developed by the National League for Nursing (2005) that measures both satisfaction and self-confidence called the Student Satisfaction and Self-Confidence in Learning Questionnaire (SSLQ) (see Appendix B).

Prior knowledge of SVT. An important aspect of how learners acquire new information is the prior knowledge that they bring with them to the new instructional environment. One principle of prior knowledge is that learners bring with them knowledge that pertains to the instructional environment but has not yet been activated by the learner (Bransford, Brown, & Cocking, 1999). In order to account for this, participants took an SVT pretest that was created by two experienced nurse practitioners and developed from existing instruments to assess SVT knowledge in the nursing curriculum. This instrument asked questions about participants' SVT knowledge (see Appendix C). The questions included:

- Which drug is the preferred intervention for terminating supraventricular Tachycardia (SVT)?
- If SVT does not respond to vagal maneuvers, how much adenosine do you give?

In order to achieve validity and reliability of the test, the nurse practitioners derived the questions from the tachycardia practice tests on the CareerCert website which provides accredited online certification for healthcare professionals (CareerCert, 2020). Validity is the extent to which the instrument accurately measures what it is supposed to measure, and reliability means that the measure consistent over time (Creswell & Plano Clark, 2011). The tests on the CareerCert website achieved reliability through a test/retest method and validity by using a medical advisory board to review the quality of their measures (CareerCert, 2020).

Delivery method. The delivery method of the SVT assessment skills instruction was an independent variable of the research design. The literature shows that technology-enhanced medical education is superior to traditional clinical education when it comes to clinical skills acquisition (Crookes, Crookes, & Walsh, 2013; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011; Sperling, Clark, & Kang, 2013). The delivery method of SVT assessment instruction was through either traditional simulation lab instruction or using IVR technology. The measurement for the delivery method was the presence or absence of the IVR instructional methodology. It was hypothesized that the IVR delivery method would have no affect on SVT assessment skills outcomes when compared to the traditional simulation lab delivery method.

SVT skills acquisition. Simulation training of SVT assessment skills has been shown to improve significantly over time (Freeland, Pathak, Garrett, Anderson, & Daniels, 2016). The dependent variable of this design is SVT clinical judgement skills acquisition. Therefore, SVT clinical judgement assessment skills were measured by using the Lasater Clinical Judgement Rubric (LCJR) during observed SVT assessments (Lasater, 2007). The LCJR (see Appendix A) has been used as a valid and reliable instrument in assessing clinical judgement. Adamson, Gubrud, Sideras, and Lasater (2012) used three different studies that employed the LCJR to determine that it is a valid and reliable instrument to assess clinical judgement in high-fidelity simulations.

The literature shows that participating in simulation created for clinical assessment significantly increases knowledge acquisition (Aebersold, Kocan, Tschannen, & Michaels, 2011; Freeland, Pathak, Garrett, Anderson, & Daniels, 2016; Lee Gordon, Issenberg, Gordon, LaCombe, McGaghie, & Petrusa, 2005). Therefore, the researcher also tested SVT knowledge acquisition by giving both groups of students an SVT posttest after the training scenario. The posttest was created by two experienced nurse practitioners and developed from existing instruments to assess SVT knowledge in the nursing curriculum. This instrument asked questions about participants' SVT knowledge. The questions included:

- You attempt vagal maneuvers, but the patient remains in what appears to be SVT. What medication should now be administered?
- What is the best (first) management strategy [for a patient presenting with SVT]?

In order to achieve validity and reliability of the test, the nurse practitioners derived the questions from the tachycardia practice tests on the National Health Care Provider Solutions (NHCPS) website which provides accredited online certification for healthcare professionals (NHCPS, 2020). The NHCPS tests achieve validity because they are designed by Board Certified Physicians and evaluated by the Postgraduate Institute of Medicine (PIM), an accredited, online medical certification regulatory organization, and they achieve reliability through test/retest methods by multiple users (NHCPS, 2020). It was also hypothesized that SVT clinical judgement skills acquisition and SVT knowledge acquisition outcomes would affect student reports of student satisfaction and self-confidence.

Student satisfaction and self-confidence. In addition to assessing SVT clinical judgement and knowledge acquisition, the intervention also measured student satisfaction and self-confidence. The literature shows that technology-enhanced medical education increases student self-confidence over a traditional curriculum (Kang, Kim, Kim, Oh, & Lee, 2015; Sperling, Clark, & Kang, 2013). Closely associated with self-confidence skills acquisition is the satisfaction that students have with the delivery method (Curran et al., 2015). Therefore, an instrument developed by the National League for Nursing (2005) was used to measure both satisfaction and self-confidence. The Student Satisfaction and Self-Confidence in Learning Questionnaire (SSLQ) has reliability greater than .87 Cronbach's alpha for both scales, and validity was established through a multistate panel of medical simulation specialists (Butler, Dawn, & Brady, 2009; Smith & Roehrs, 2009). The use of this instrument helped support the dependent variable outcomes (see Appendix B) by measuring the effects of the SVT curriculum delivery method on the students' reported satisfaction and self-confidence. Another dependent variable in this design was the participants' experience using IVR.

Experience using IVR. In a mixed methods embedded research design, qualitative data are gathered in order to support the results of the primary quantitative data (Creswell & Plano Clark, 2011). Therefore, the researcher conducted a semi-structured interview designed to gather information about participants' experiences with the IVR delivery method (see Appendix D). Sample questions included the following:

- Describe the things you enjoyed about the IVR delivery method.
- Describe the things you disliked about the IVR delivery method.
- Think about how you felt during the immersive experience. Describe what that felt like.
- In what ways did the IVR delivery method affect your learning of the material?

Validity for the semi-structured interview was established through member checking and through reporting of disconfirming evidence.

Procedure

The following sections will include a detailed description and timeline of the intervention as well as an explication of the data collection procedure and data analysis. The proposed intervention used IVR as a supplement to SBME, where the student can repetitively engage in these simulated scenarios at their own convenience. This intervention, if successful, would allow the user to experience more realistic environments, replay the scenarios, have scaffolded information and data analytics, and cost significantly less to run and maintain.

Intervention

The intervention took place over two consecutive Tuesdays at the end of February 2020 and the beginning of March 2020. The scheduled days allowed the researcher to observe between eight and nine participants per day (four participants per experimental and control group) for a total of N=19 over the course of two days. Students were given a consent form and the researcher obtained permission in writing. Students were also informed that they could remove themselves from the study at any time for any reason. On the designated day, nursing students in the control group arrived at Midland University's simulation lab to experience a SVT simulation scenario that is part of their existing curriculum. The experimental group arrived to a designated room on the Midland University's campus to participate in the same SVT scenario, but through an IVR delivery method. Students received a reminder email at the beginning of the week about the intervention. Students were also randomly assigned to either an experimental group that used the IVR delivery method of instruction, or a control group where they went through the traditional simulation scenario curriculum. The experimental group participants were provided with up to 20-minutes of an orientation session to experience the IVR technology and software. The control group went to the patient simulation room where the HAL manikin ran through a pre-programed SVT simulation scenario. During both scenarios, trained nurse practitioners observed the students' performance and scored their clinical judgement using the LCJR. After both scenarios, the students participated in a 10-minute debriefing session. They then completed an SVT posttest, and a post-intervention questionnaire (SSLQ). These procedures will be further broken down by equipment, student activity, researcher activity, and timeline.

Equipment and software. The equipment and software for the experimental group included an Oculus Go virtual reality HUD and controller, an iPad connected to a television monitor so that the observers could see what the student sees, and a software program that displayed the immersive virtual reality scenario in the HUD. The IVR scenario was an immersive 360-degree video recording of a simulation lab SVT scenario using the HAL manikin. The video was pre-recorded and certain locations on the video were tagged using IVR video manipulation software. This allowed the student to perform certain functions in the immersive environment just as they would be able to in an actual simulation scenario or clinical experience. The recording was of the exact same scenario that the control group experienced in the simulation lab and was filmed from the perspective of the student standing at the patient's bedside.

The control group equipment and software consisted of a HAL, high-fidelity mannikin that ran an SVT scenario that was pre-programmed using simulation software. The room also had a vital signs monitor, a computer station, and cabinet stocked with medication that would need to be administered as part of the simulation scenario assessment. Each of these locations in the actual simulation lab scenario were tagged and were accessible using the HUD controller in the IVR scenario.

Student activity. The participants completed a prior knowledge of SVT pretest (CareerCert, 2020) before the intervention. The experimental group then participated in an allotted 20-minute IVR orientation session to familiarize themselves with the equipment and the software. This orientation session consisted of fitting and adjusting the HUD onto their heads so that it was comfortable, and they could see the video. They were also oriented to the controller and its functionality by manipulating a test video. The test video did not contain any subject matter related to the SVT assessment scenario. The experimental group then went through an approximately 30-minute immersive SVT assessment scenario and used the controller to perform certain clinical judgement actions that might result in successful patient management. The control group also went through a 30-minute SVT assessment scenario in the traditional simulation lab room using the HAL high-fidelity mannikin (see table 4.2). Both groups then participated in a 10-minute, individual debriefing session after the scenario. Once the debriefing session was completed, all participants completed the SSLQ (NLN, 2005). Finally, the students in the IVR group participated in a semi-structured interview to collect qualitative data on their experience with the delivery method.

Table 4.2

Comparison of Immersive Virtual Reality Scenario and Traditional Simulation Lab

	IVR	**Traditional Simulation Lab**
Participants	*n* = 9	*n* = 9
Equipment	Oculus rift HUD; haptic controller; iPad, television monitor	HAL high-fidelity mannikin; monitor; computer
Facility Space	Any space with a WiFi connection; research conducted in room on Midland University campus	Dedicated simulation lab wing of a hospital or training facility, converted hospital room
Content Delivery	SVT curriculum 360 degree immersive video with interactive content	SVT curriculum through a high-fidelity mannikin

Researcher activity. The researcher's activities closely paralleled the activities of the students. The researcher checked all equipment and software prior to the intervention to ensure that everything was working properly. The researcher distributed the questionnaires and facilitated the 20-minute orientation session. Trained observers observed both groups of students during the SVT assessment scenario and recorded data from the LCJR (Lasater, 2007). The researcher also helped conduct the debriefing session for both groups and distributed the post-intervention questionnaire. The researcher then collected and analyzed all data from the intervention over the course of a month.

Timeline. The participants were selected and randomly assigned to their respective groups at the end of February 2020. The recording of the scenario and software coding for the IVR experimental group took place in early January 2020 and the intervention occurred over two consecutive Tuesdays in late February and early March 2020. Table 4.3 provides a detailed

Table 4.3

Timeline of Intervention

Calendar 2020	Intervention Component	Estimated Time
January	Recruitment	1 month
First two weeks of January	Video filming and software coding	2 weeks
End of February	Intervention	90-minute intervention per participant over four days
Intervention Day	Pre-intervention questionnaires	10 minutes per questionnaire for a total of 20 minutes
Intervention Day	IVR equipment orientation session	20 minutes
Intervention Day	IVR and traditional simulation stroke assessment scenario	30 minutes
Intervention Day	Post-intervention questionnaire	5 minutes
Intervention Day	Debriefing session	10 minutes
Intervention Day	Semi-structured interview	10 minutes
February through April	Data collection and analysis	3 to 4 months

view of the timeline. During the intervention, the researcher systematically collected data for later analysis. The questions on this semi-structured interview were designed to gather qualitative information about the IVR intervention experience that helped explain the quantitative results.

Data Collection and Storage

The quantitative data were collected through pre and posttests, questionnaires, LCJR, and observations. The questionnaires were created and administered using Google Forms. The questionnaires were accessible via a secure internet connection and private link. Students were given a link to the questionnaires and completed them on the researcher's password-protected computer. Responses to questions were also stored on the researcher's password-protected computer in the researcher's private and password-protected Google Drive. The Google Forms questionnaires were accessible by the researcher via a secure login and password. Student responses contained no identifiable information. Quantitative data during the SVT assessment scenario were collected through observation and recording with the LCJR (Lasater, 2007). Observational quantitative data included items such as how long it took the student to orient themselves to the IVR equipment, time spent making clinical judgements, and whether those clinical judgements were appropriate for the successful management of a patient presenting with SVT symptoms.

The qualitative data consisted of responses to the SSLQ (NLN, 2005) as well as observations during the debriefing session and responses given to the research during the semi-structured interview. Responses to both the questionnaire and semi-structured interview were collected by the researcher and stored on a password-protected computer for analysis. The semi-structured interview gathered more qualitative data for quantitative data explanation. In addition to the aforementioned storage procedures, both quantitative and qualitative data were stored on an external password-protected backup drive.

Data Analysis

The quantitative data was exported from Google Forms via a csv file and imported into SPSS for analysis. The data were analyzed for significant correlations between the research variables and for differences in LCJR scores between the treatment and control groups. The data from the treatment group and the control group were compared by an independent *t*-test (p=.05) to analyze clinical judgement, as well as SVT knowledge acquisition when caring for a symptomatic SVT patient. Participants' clinical judgement skills and satisfaction and self-confidence were measured on the LCJR and SSLQ respectively. Descriptive statistics were also collected for the two groups and correlations examined to see if there were relationships between student satisfaction of IVR use and learning outcomes.

The qualitative data collected from the semi-structured interview were thematically coded using inductive reasoning. The researcher looked for emergent themes in the semi-structured interview that related to student satisfaction, dissatisfaction, self-confidence, desire for repetitive practice, and suggestions for improvement. The researcher analyzed the qualitative responses by listening to and transcribing the audio-recorded interviews. Then the researcher recorded key words, themes, and emotions, and reflected on the effect they may have on the quantitative results.

Process Evaluation

The proposed intervention in the above research methods section included a process evaluation plan (see Appendix E). Process evaluation is necessary because it allows the researcher to look into the black box of the research design process and determine which factors might have affected the results (Rossi, Lipsey, & Henry, 2018). It was necessary for this research design because the implementation process needed to be examined in order to ensure that the intervention was implemented correctly. The proposed intervention asked the following process evaluation research questions (PERQs):

PERQ1	Did learners feel that a 20-minute orientation session with the IVR equipment was enough time for them to become familiar with its use for the subsequent instructional session?
PERQ2	To what degree did the implementation of the IVR instructional method align with the intended research design?
PERQ3	What was students' level of participation during the IVR instructional method?

Process evaluation is a means by which components that affect how an intervention is implemented and received can be assessed by the researcher (Baranowski & Stables, 2000). This process evaluation plan considered the evaluation question through an explanation of four evaluation components; program implementation, the context of the intervention, participant responsiveness, and barriers.

Program Implementation

Program implementation is comprised of reach, dose, dose received, and fidelity (Linnan & Steckler, 2002). In order to address program implementation, the researcher gathered quantitative and qualitative data on the implementation of the orientation session prior to the IVR intervention. This orientation session was given to all nine of the nursing students participating in the experimental group. All participants received a 20-minute orientation session to familiarize them with the use and functionality of the IVR equipment. The orientation session followed an orientation protocol that covered the IVR hardware and software in a systematic way. This was measured through quantitative data analysis that included orientation time, number of participants, and checklists that measured orientation protocol adherence (see Appendix F). Qualitative data consisting of responses to post-intervention interviews were collected to determine what participants thought about the orientation session. This component is reflected in the activities section of the logic model (see Figure 4.1) and when implemented with fidelity, it was hypothesized that it would lead to successful IVR use during the instructional method and the subsequent outcome of SVT assessment skills.

The process evaluation plan concerning PERQ2 was measured as a component of the context of the intervention. The context is defined as the environment in which the intervention takes place (Baranowski & Stables, 2002). The context for the intervention for the control group was at Methodist Fremont Health's simulation lab and the context for the experimental group, including the 20-minute orientation session, was in a dedicated room on Midland University's campus. Other contextual elements for the orientation session included a well-lit room with a display monitor, an iPad, an Oculus Go virtual reality headset and controller. The context was measured quantitatively by assuring that all equipment was counted present and available for use during the orientation session and qualitatively through a post-intervention semi-structured interview that asked the participants if they felt the room provided adequate space for movement and if the equipment was comfortable and adjusted to fit each user's preferences. This component aligned with the input section of the logic model where equipment and facility space were described. When the context was implemented with fidelity, it was hypothesized that there would be an increased chance that the orientation session would succeed in familiarizing participants with the equipment.

The process evaluation plan concerning PERQ3 was determined through participant responsiveness. Participant responsiveness relates to the ways in which participants viewed their participation in the intervention (Dusenbury, Brannigan, Falco, & Hansen, 2003). For the orientation session there was a goal that 90% of the participants would feel that the orientation protocol helped them understand how to use the IVR equipment and successfully navigate the virtual environment. This was measured quantitatively by looking at whether the protocol checklist was completed for each participant and qualitatively through a post-intervention semi-structured interview designed to gather participants' impressions on each element of the orientation protocol. This component aligned with the logic model in the output section, where participant feedback on the orientation protocol was used to revise the orientation where necessary. It was hypothesized that if this component was implemented with fidelity, then the participants would have an easier transition from the orientation session to the instructional session.

Barriers

Barriers in process evaluation relate to problems that may prevent participants from receiving the program (Baranowski & Stables, 2002). The barriers that may be present in the orientation, research context, and participant responsiveness are hardware and software malfunctions, deviation from the orientation protocol, and the participants having adverse reactions to the virtual environment. This component was measured quantitatively by the number of incidents of these barriers per orientation session as well as qualitatively by a post-intervention semi-structured interview that asked participants about perceived barriers. Though not explicitly indicated in the logic model, any barriers discovered during the activity phase, served as data to revise the implementation of the orientation.

Process Indicators

It was necessary to look at several process indicators to determine if the orientation session was implemented in a way that effectively oriented students to the IVR equipment and virtual environment. These indicators are derived from the process components outline above and consist of the residents' attendance, the delivery of the orientation protocol, residents' participation in the orientation session, and the functionality of the equipment (see Appendix G).

Resident Attendance

The 20-minute orientation session was designed to familiarize the learner with the IVR equipment, as well as expose them to the virtual environment and how they would be able to navigate within that environment during the instructional session. The orientation session would only be successful if all residents in the experimental group attended the session. The attendance of the orientation session was aligned in the activities section of the logic model and fell under the orientation session description.

When the residents arrived for the intervention, their attendance was recorded by the simulation lab administrator and researcher on an attendance sign-in sheet. There were two IVR kits for participant use. This was a precaution that was taken against the short battery life of the units. By having two headsets, the researcher was able to charge one unit while the other unit was in use so that each attendant could participate right after the other one had finished. The attendance sheet was collected by the researcher after each orientation session and checked against the participant list to ensure that all residents in the experimental group attended the orientation session.

Delivery of Protocol

The orientation was delivered in a systematic way to ensure that each of the important elements of the orientation were covered. These elements included, fitting the Oculus Go unit to the participant's head, body positioning and tracking, using the controller, and navigating within the virtual environment. These elements were further broken down into an orientation session protocol checklist that was covered by the researcher. This helped reduce variation in orientation instructions and allowed each participant to have consistent information about how to use the IVR equipment and software. The delivery protocol was present in the logic model as an output from the activities. It was considered an output because the protocol checklist was a product created from the orientation session activity and was continuously revised to improve the orientation experience of the participants.

The systematic delivery of the orientation protocol was implemented by the researcher and the researcher marked the checklist when each orientation element had been completed by the participant. Those data were collected for each participant during each orientation session for a total of nine completed checklists. The researcher reviewed the checklists to see if the protocol was followed in each instance and whether participants were able to successfully complete each of the orientation elements.

Medical Learner Participation

The medical learners' participation in the orientation and process was a key indicator in determining if the orientation session and subsequent SVT scenario were successful. The participation provided value feedback on dose (Linnan & Steckler, 2002), the IVR equipment, and the virtual environment. Medical learner participation consisted of attending a 20-minute orientation session where they used the IVR equipment and familiarized themselves with the virtual environment. Medical learners also participated in orientation activities within the virtual environment that required them to navigate the environment as well as use the controller to interact with objects. This participation is reflected in the logic model in the activities section and was a necessary prelude to participating in the instructional session.

The data for participation were gathered both quantitatively and through participant responsiveness (Dusenbury, Brannigan, Falco, & Hansen, 2003). The software recorded the participants' interactions with the virtual environment and was reviewed to understand user mistakes and challenges navigating the activities. This information was collected and reviewed after each participant's session for a total of nine scenarios. The qualitative data were gathered after each debriefing session through semi-structured interviews administered by the researcher. The interviews elicited participant responses on what they thought about the orientation session. Specific questions asked about the dose, the comfortability of equipment, and if there was enough time to familiarize themselves with the equipment and the virtual environment. After data were collected, the researcher gathered and reviewed the audio taped interview responses by listening to the audio recordings multiple times and then transcribing them into a spreadsheet to determine if adjustments to the orientation session needed to be made.

Functionality of Equipment

The final process indicator for the orientation session was the functionality of equipment. The IVR equipment, the iPad, the television monitor, and the software that creates the virtual environment were all included in this indicator. The success of the orientation session and the subsequent instructional session were dependent on all of these components working correctly. However, over the course of nine sessions, the researcher hypothesized that the participants would inevitably encounter some challenges with equipment performance. This was reflected in the inputs section of the logic model but was also part of the activities. During instances when the equipment was not operating as expected, it would be necessary to gather data on the malfunctions so that improvements could be made.

Data were gathered through a combination of error logs reported by the software as well as a spreadsheet that the researcher used to keep track of every instance where the equipment was performing less than optimally. The spreadsheet had sections for monitor functionality, the IVR equipment, and the virtual environment software. Any malfunctions were compiled during and after each session and the researcher reviewed the data to determine how to improve functionality.

Outcome Evaluation

The outcome evaluation plan was centered around the following questions:

OERQ1	A. What is the change in medical learners' clinical judgement skills after SVT assessment in an IVR instructional delivery method compared to medical learners using a traditional simulation lab instructional delivery method? B. What is the change in medical learners' SVT knowledge acquisition after SVT assessment in an IVR instructional delivery method compared to medical learners using a traditional simulation lab instructional delivery method?
OERQ2	What is the change in medical learners' confidence level in assessing a SVT after and IVR instructional delivery method?
OERQ3	What is the medical learners' perception of satisfaction with the instructional delivery method?

The null hypotheses was that there would be no change in skills acquisition scores from pretest to posttest between the experimental and control groups as indicated by an independent *t*-test and that there would be no increase in the satisfaction and confidence level of medical learners as indicated in a post-intervention survey and semi-structured interview.

Effect Size

Calculating the effect size is an important way to measure the effects of an intervention, which is represented by the standardized mean difference between the results of the intervention group and the results of the control group (Lipsey et al., 2012). In order to calculate the effect size for this intervention, this study used Hill, Bloom, Black, and Lipsey's (2008) suggestion to use empirical benchmarks of effects observed in similar interventions.

A systematic review of the effects of simulation-based medical education on standardized learning outcomes calculated the average weighted effect size for 32 studies at 0.81 (McGaghie, Issenberg, Petrusa, & Scalese, 2006). This effect size can be considered appropriate for the proposed IVR intervention, because the design will have medical learners practice in the simulator and immersive virtual environment from 30 minutes to one hour. Another meta-analysis by Cook et al. (2013) looked at knowledge outcomes for technology-enhanced simulation education and found that knowledge outcomes had a pooled effect size of 0.86.

Another study that provided an effect size range for this intervention is one by Tawalbeh and Tubaishat (2014) that looked at the effect of simulation on knowledge of advanced cardiac life support skills (ACLS) and retention. The authors' experimental research design is very similar to the proposed intervention and they calculated a medium effect size of 0.50 for their study. It was proposed that the IVR intervention would have an effect size range between 0.50 and 0.80. The use of G*Power software was used to calculate the effect size for the proposed intervention using numbers published in the research. A *t*-test of the difference between two independent means shows that an effect size of 0.50 with a power level of 0.80 requires a total sample size of 102 participants. This means that the original target sample size of 45 medical learners would have to show a large effect size at 0.80, where the sample size is then calculated at 42 participants. The sample size for the intervention was only 18 participants, so the effect size in this study had higher variability and an increased chance for type II error. However, a similar study by Butt, Kardong-Edgren, and Ellertson (2018) found that a sample of 20 nursing students using game-based VR for skills acquisition had a statistically significant increase in skills practice time over students who practiced traditionally.

Outcome Evaluation Design

The intervention used a randomized controlled trial (RCT) design. This design has a long history in medical research and uses random selection to place participants in and experimental and control group, which has become the gold standard in medical research (Bothwell, Greene, Podolsky, & Jones, 2016). This design was selected because it is considered the gold-standard of research design and that any differences in groups are most likely because of treatment effects rather than the differences between the groups prior to the study (Shadish, Cook, & Campbell, 2002). The RCT design fits well with the outcome evaluation question because determining the acquisition of SVT skills based on the instructional delivery method requires that the sample be split into a control group and a treatment group.

Sampling and Grouping.

The target population for the RCT design was senior-level nursing students from Midland University and Methodist University (N=18). They are at a level in their training where they are expected to dramatically increase their knowledge and skills in clinical settings and are expected to assess an SVT patient for continued and informed management. Furthermore, SBME is an important part of nursing training, as it helps bridge the gap from theory to applied practice and increase confidence when exposed to real patients and medical situations. Thus, they were able to participate in a project that used IVR as a delivery method for SVT assessment. The sample was randomly assigned to two groups, a treatment group that used IVR as the SVT assessment instructional delivery method and a control group that used a SVT assessment curriculum in a traditional simulation lab delivery method. The groups were randomly assigned using a sealed envelope method (Ahlberg, Hultcrantz, Jaramillo, Lindblom, & Arvidsson, 2005).

Testing

A pretest-posttest design was used in order to control for any variance between groups (Leviton, 2007), and to establish a baseline of SVT skills knowledge acquisition scores that could be reassessed after the intervention to analyze any knowledge gains. After the pretest the experimental group underwent 20 minutes of instruction and orientation related to the use of the IVR equipment. Then both groups spent approximately 30 minutes in an SVT assessment instructional scenario, with the experimental group using the IVR equipment and the control group using a traditional simulation lab and manikin. After the instructional period, both groups took a posttest where the treatment effect would be inferred by comparing the posttest mean between groups (Torgenson, Torgenson, & Taylor, 2015). There was relatively little time between pretest and posttest, so in order to mitigate any threats to validity from testing effects, the posttest employed item response theory so that tests were different but were still measuring the same SVT assessment construct (Shadish, Cook, & Campbell, 2002).

Data Collection and Analysis

Data were collected following a mixed-methods design. The reason for this was that a mix of qualitative and quantitative data would help reduce unintended consequences and provided analytical insight into the pretest-posttest design that typically suffer validity issues

(Bamberger, Tarsilla, & Hesse-Biber, 2016). There were three main indicators that the design sought to explore. These were the medical learners' ability to assess and treat an SVT patient, the learners' perceptions of self-confidence in an SVT assessment scenario, and the learners' perceptions of satisfaction with the IVR instructional delivery method. Data for each indicator were collected from a mix of quantitative and qualitative methods (see Appendices A & B). The design also considered the control variable of time spent in the simulation scenario so that the amount of time was constant and did not affect the outcomes.

Strengths and Limitations

The strength of this study was that it used a mixed-methods, RCT experimental design with a pretest-posttest. Using an RCT experimental design helps to eliminate differences between groups that may affect outcomes (Shadish, Cook, & Campbell, 2002) while the mixed-methods approach helps to reduce unintended consequences and offer qualitative analysis to improve the validity of the pretest-posttest design (Bamberger, Tarsilla, & Hesse-Biber, 2016). Another strength was that research supports the use of simulations to improve medical knowledge and skills (Cook et al., 2013) and RCT is a strongly suggested research design in medical education (Torgerson & Torgerson, 2008). A quasi-experimental comparison group design was briefly considered to compare the treatment group with a group that did not receive treatment but was ultimately rejected because of concerns over selection bias (Flannelly, Flannelly, & Jankowski, 2018).

There were three challenges to this design that needed further consideration. The first was sample size. Given the current sample size of 18 medical learners, the effect size would need to be 0.80. A medium effect size would require that the sample size was more than five times that amount at approximately 100 medical learners, which is a number that was not attainable in the research context. However, if there were increases in SVT assessment knowledge acquisition between pretest and posttest, there would not need to be a significant difference between the treatment group and the control group, because showing that IVR instruction as a delivery method is equivalent to traditional simulation training would be a valuable outcome of the intervention. Second, the intervention followed a short timeline and the medical learners were only exposed to the treatment and control group once during the study. This was a limitation that was constricted by the research context.

Third, the pretest-posttest design also presented some validity challenges that are part of the testing effect (Shadish, Cook, & Campbell, 2002) but there were plans to mitigate this threat through item response theory (Lord, 1980) and the Solomon Four Group Design (Braver & Braver, 1988). Also, there would be a continuous exploration to increase the amount of time between pretest and posttest.

The outcomes evaluation design would be able to answer whether or not there were any differences in the acquisition of SVT assessment knowledge between the treatment group and the control group. If the treatment group had statistically significant increases in SVT assessment knowledge compared to the control, then there would be an inference that the IVR delivery method can be used to educate medical learners. Even if there was no statistical difference between these groups, the same can be inferred because traditional simulation instructional methods have been shown to increase knowledge and skills acquisition (Issenberg et al., 2005). If the treatment group scores were significantly lower on the posttest, then the analysis of the moderating and mediating variables could be used to help explain the results.

Chapter 5 – Findings and Discussion

The purpose of this study was to examine the efficacy of IVR for placing medical learners in a virtual clinical scenario where they could experience and practice the care and management of a virtual patient.

The intervention used IVR to teach senior-level nursing students' SVT patient assessment skills with the intended purposes that successful outcomes would afford opportunities for repetitive practice. This chapter will describe the process of the intervention implementation for both the IVR experimental group and the traditional simulation control group. The goal of this chapter is to provide research results organized by both process and outcome research questions and discuss how these results may impact the future of medical education. Then the chapter will look at the limitations of the study and its implications for future research. Finally, the chapter will conclude with overall recommendations and next steps for medical and nursing schools that want to provide avenues for repetitive practice for their learners.

The researcher collected both qualitative and quantitative data to inform the process and outcome questions. The research questions for this study were as follows:

Process evaluation research questions (PERQs):

PERQ1	Did learners feel that a 20-minute orientation session with the IVR equipment was enough time for them to become familiar with its use for the subsequent instructional session?
PERQ2	To what degree did the implementation of the IVR instructional method align with the intended research design?
PERQ3	What was students' level of participation during the IVR instructional method?

Outcome evaluation research questions (OERQs):

OERQ1	A. What is the change in medical learners’ clinical judgement skills after SVT assessment in an IVR instructional delivery method compared to medical learners using a traditional simulation lab instructional delivery method? B. What is the change in medical learners’ SVT knowledge acquisition after SVT assessment in an IVR instructional delivery method compared to medical learners using a traditional simulation lab instructional delivery method?
OERQ2	What is the change in medical learners’ confidence level in assessing an SVT patient after and IVR instructional delivery method?
OERQ3	What is the medical learners' perception of satisfaction with the instructional delivery method?

These research questions will be used to frame the discussion of the findings.

Fidelity of Implementation

In order to understand the answers to the process evaluation research questions, it is necessary to describe the research context and the shifts in procedure that resulted from technical challenges. Participants were recruited from both Midland University’s School of Nursing and Nebraska Methodist College of Nursing and Allied Health. Multiple attempts were made to recruit a targeted N of 45 students, including multiple emails and in-person visits to the students’ classrooms to solicit participation. A total of 18 students participated (nine in the experimental group, and nine in the control group) over two sessions at the end of February and the beginning of March 2020.

The recruited participants were randomized into an experimental group and a control group. Both groups of participants were informed to arrive at Methodist Fremont Health Hospital and proceed to the Midland University Simulation Lab where the intervention would take place. The control group participated in the intervention by going through a traditional simulation using a high-fidelity mannikin to assess an SVT patient, while the experimental group participated in an IVR simulation using an Oculus Go virtual reality headset. The students in the experimental group went through an orientation of the IVR equipment in order to ensure that they would be comfortable using the technology during the intervention. This orientation session and the subsequent IVR intervention were observed by the researcher and a trained nurse practitioner. A semi-structured interview provided the data for PERQ1.

Orientation Session

The first process evaluation research question sought to determine whether the participants felt that an orientation session with an allotted time of 20 minutes was enough time for them to properly orient to the IVR equipment. Though participants were allowed up to 20 minutes for the orientation session, they were told to inform the researcher when they felt that they were ready to proceed with the SVT scenario. In addition to quantitative analysis (see below analysis for PERQ2), the researcher conducted a semi-structured interview to ask questions about the orientation session. An analysis of inductive coding and theme identification revealed several interesting concepts including time of orientation, ease of use, and orientation tasks (see Figure 5.1).

Time of orientation. The participants were asked about the orientation session and whether or not they felt that 20 minutes was enough time to get orientated to the IVR equipment and functionality. With one exception, all of the participants thought that the time provided for orientation was more than adequate. Most participants elected to continue with the SVT scenario within five minutes of starting the orientation. Regarding the amount of time, Participant 2 said "I think it's [orientation session time] pretty adequate…I enjoyed it, especially the view". The view that the participant is referring to is an IVR beach scene where all participants were immersed during the orientation. The scene was selected as a tranquil backdrop to the orientation to aid in the reduction of anxiety. Participant 1 also felt that enough time was provided during the orientation session by remarking:

> I think that was adequate for the simulation experience. I think that was enough [time] to help you with the experience cause [*sic*] even with the remote, just showing where to put your fingers and whatnot was pretty much all you needed.

This indicates that the 20-minute orientation was more than adequate for participants to familiarize themselves with the IVR equipment.

Ease of use. Another theme that emerged during the semi-structured interview was the participants' discovery of how easy the IVR equipment was to use during the orientation session. The ease of use was equated to three main tasks (a) adjusting the Oculus Go headset to their heads so that it was secure but comfortable, (b) looking around in the IVR environment and tracking objects with head movement, and (c) using the Oculus Go controller to interact with IVR objects. Participant 2 commented that "It's pretty simple to use; not too difficult, just move it [the headset] around even the remote was pretty easy to maneuver".

Participant 8 said "It was kind of surprising how it seemed very easy to use—not too complex or difficult to use. [I] got used to it pretty fast." In addition to the participants' answers to interview questions, ease of use is also reflected in the orientation time because spending one quarter of the allotted time orientation indicates that the equipment was not complex enough to warrant more time. This might also be attributed to the commercial design of the Oculus Go. Designed by Facebook, the IVR equipment was created with consumer satisfaction in mind as well as a low barrier to entry.

Orientation tasks. Other themes that emerged from the orientation session were the orientation tasks themselves. While most participants were satisfied with the orientation session overall, there were some participants who felt that the orientation session should have included some additional tasks. Participant 4 said:

> I think it would have been more helpful if you could click on something within the orientation session so then when you click on it in the scenario then you have more of an idea of what exactly you're doing.

Participant 1 would have liked "…feedback on how to start and what you're supposed to be doing". The interviews suggest that even though there was adequate orientation time and the IVR equipment was easy to use, some additional tasks and information would have helped the participants perform better in the SVT scenario.

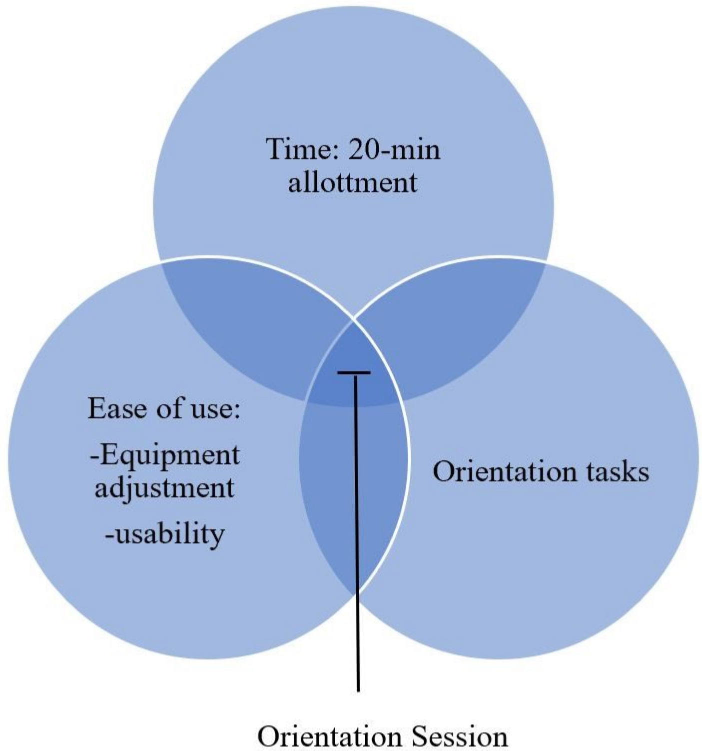

Figure 5.1. Orientation semi-structured interview themes.

IVR Instructional Method Alignment

The answer to PERQ2 was dependent on the delivery of the orientation session protocol to the IVR group and the functionality of the equipment. The latter variable presented a challenge early in the intervention. The researcher wanted to have both groups participate in the intervention in the same location (Midland University Simulation Lab) so that the researcher could observe both groups. However, the secure hospital Wi-Fi would not allow the Oculus Go headset to connect to the wireless internet service, which was a critical component of being able to run the IVR intervention. Therefore, the researcher had to relocate the experimental group to Midland University's campus in order to use the Wi-Fi and successfully implement the IVR intervention. Consequently, there was a time delay in starting the intervention for the IVR group, so participant 1 had a shortened orientation time of ten minutes. However, as explained in the previous section, all participants felt that a 10-minute orientation session was an adequate amount of time to adjust to the equipment and learn how to operate in the immersive virtual environment.

Orientation session. An orientation protocol checklist was present on the researcher's iPad (see Appendix F) and the researcher checked each box after each procedure was implemented. A quantitative analysis of the orientation protocol checklists showed that every checklist item was completed for all participants. Concerning the fifth item in group 1 of the checklist, participants were told to give verbal acknowledgement when they felt that they were comfortable with IVR equipment and understood how to operate the controls within the IVR environment. Table 5.1 provides participant data in regard to their participation in the orientation session. Quantitative analysis showed that the average time was 4 minutes and 51 seconds for a participant to respond that they were oriented and ready to continue to the intervention scenario. This was far below the allotted time of 20 minutes for each orientation session. As indicated in the discussion for PERQ1, every participant felt that the time they had was adequate, did not feel rushed, and that 20 minutes would have been too much time. This indicates that there was high fidelity in the orientation session of the IVR delivery method.

Table 5.1

IVR Orientation Session Participation

Participant	Orientation Checklist Completed	Time of Orientation Session (min)
1	Yes	5.32
2	Yes	4.15
3	Yes	3.45

Table 5.1 (continued)

4	Yes	5.2
5	Yes	7.11
6	Yes	4.5
7	Yes	3.15
8	Yes	4.41
9	Yes	3.30

Functionality of equipment. The Oculus Go virtual reality headset is a wireless, stand-alone device that operates on battery charge. It also includes a wireless hand controller that is used to interact with the immersive virtual environment. In order to ensure that intervention sessions would not be interrupted by loss of power, the researcher had two Oculus Go units so that one could be charged while the other one was in use. A supply of batteries was also on hand to support the operation of the hand controller. The intervention software that ran the SVT simulation was downloaded to both units and placed within the units' browser queue so that it could be easily accessed by the participant. The Oculus Go was connected via secure Wi-Fi to an iPad application that allowed the content of the unit to display on the iPad via screen cast. The iPad was in turn connected to a large flat-screen television via AppleTV so that the researcher and the nurse practitioner could view what the participant was looking at and experiencing in real time. This method allowed the skilled nurse to observe and evaluate the participants as they engaged with the SVT simulation. The researcher kept track of the equipment during the intervention and logged any technical errors that occurred (see Appendix G) in order to assess the alignment of the instruction with the intended research design. The research design operated on the assumption that there would be very few technical errors affecting the intervention.

There were only two instances of equipment issues recorded during the IVR intervention. The first was explained earlier and had to do with the IVR headset not being able to connect to the hospital's Wi-Fi. The second was an issue where the software used for the IVR intervention quit a few minutes into the SVT scenario. It is probable that the participant accidentally touched the exit button on the controller which would have forced the participant back to the introduction screen of the program. However, the researcher did not observe the participant accidentally pressing the exit button at that time, and so it was recorded as an issue with the software. The participant was placed back into the IVR scenario and there were no further issues. These were the only two equipment issues that were recorded during the approximately 5 hours and 30 minutes of total intervention time. Therefore, the researcher concluded high fidelity in research alignment regarding the functionality of the IVR equipment.

Level of Participation

The nursing students were measured on their participation level by using an attendance and participation tracker (see Appendix H) that logged their attendance, whether they completed the orientation session, whether they participated in the entire IVR instructional lesson, and their self-reported level of participation during the semi-structured interview. Quantitative analysis of the attendance and participation tracker showed that 100% (n=9) of nursing students attended the intervention. The participants were told during the orientation session that they could quit the IVR simulation at any time by either informing the researcher that they were done, or by simply removing the Oculus Go headset. Even though they had this option, 100% (n=9) of the students completed both the orientation session and the IVR simulation in its entirety.

After the intervention, the nursing students participated in a semi-structured interview where the researcher asked questions about their perceived level of participation. All of the participants replied that they felt engaged and participated fully in the intervention. However, after analyzing the interview data, the researcher discovered several themes that may have affected the participants' level of participation. The two themes that emerged were presence and communication.

Presence in the simulation. When people experience IVR, they have a strong sense of presence in that environment (Hoffman et al., 2014). The researcher anticipated that this sense of presence would give the participants motivation to participate in an SVT scenario that was designed to mimic a clinical experience. Participant 5 remarked that the experience was like "Déjà vu, like I've been there before. It was just like a normal one [traditional simulation], like the simulation lab in Fremont, so everything was familiar". Participant 9 also commented on their sense of presence. "It's a really good training experience because it puts you in the hospital room". Similarly, participant 4 said that "it brought me back to simulation when you're in the patient's room with the mannequin and just trying to make it as real as possible". These statements indicate that students felt like they were participating in a real-life scenario despite the curriculum being delivered via IVR.

However, the IVR environment contained features that interrupted their sense of presence. For example, the viewpoint of the scenario affected users' sense of presence. Participant 7 said:

> It was kind of weird that you couldn't walk around the room—you just had to look and point. So I don't know if you can get it to the point where we could walk around, move around—that would make it more realistic.

Participant 6 also commented on this aspect by saying "it was weird looking at it [the scenario] from that viewpoint. Like usually you're right next to and kind of looking at them [the patient]." The participant was referring to the camera placement when creating the IVR scenario. The camera had to be positioned in a stationary position near the manikin's patient bed. This viewpoint was restrictive in that the participant felt that they could not get as close to the patient as they normally would have in trying to assess their condition.

Some of the participants illustrated the way that they had to interact with the environment was different from what they were used to doing in a traditional simulation. Participant 2 said that not knowing what they could manipulate in the IVR environment was an issue:

> I think just kind of knowing the layout of the environment like kind of where things were like the med drawer…I know you said I'm able to click on stuff but I wasn't sure. Like, I didn't want to click on everything and then something not pop up.

Participant 7 also commented on the clicking aspect of the scenario by saying "it was a little bit different having to click on everything to see it." Participant 8 also had a similar experience, "I don't really know how to go about it [patient assessment] because at first I just didn't know what to click on". Participant 6 felt that having visible tags on objects that they could click on in the environment would have been helpful. "You could put the icon there [on the med drawer] so you can show what you need to click on." However, when asked a follow-up question about this the participant added:

> But I almost feel like as a senior I should know like what I do need to click on, like the steps I do need to take. So I mean in a sense you could [add visible tags] if you are just starting to teach them how to work in the sim lab.

These statements were helpful in understanding how the IVR scenario was perceptually different from the traditional sim lab environment.

Communication. The SVT scenario that the researcher created in the IVR environment did not have the capability of voice recognition and response. Many of the participants commented that not being able to communicate with the patient affected their level of participation. Participant 3 remarked: “I think one thing that would help is like if we get the patient or manikin to talk or respond”. Participant 6 also felt the same way, “It’s kind of like hard when you ask them a question you usually get a response back. It’s kind of hard when you ask ‘how are you feeling?’ and they don’t respond back.” Participant 4 also took issue with this limitation, stating “[The IVR scenario] was also more difficult because the manikin couldn’t talk back about some of the stuff…like the other aspects of the physical assessment that you can’t ask the manikin while he’s sitting there.” Participant 4 suggested that adding voice to the manikin, even if he was not able to respond to questioning would have increased participation. For example, if the manikin said something “like ‘hey my chest is hurting,’ or ‘my pain’s increasing’ I would have done like morphine to decrease respiration or something along those lines.” These statements made it clear to the researcher that having the manikin communicate with the user would have been beneficial in increasing the nursing students’ level of participation in the SVT scenario.

Knowledge Acquisition and Clinical Judgement

The first outcome evaluation research question (OERQ1) investigated the differences in medical learners’ SVT knowledge acquisition and clinical judgement skills after an IVR instructional delivery method compared to a traditional simulation lab instructional delivery method. First, this section will discuss SVT knowledge acquisition findings from pretest -posttest data for both groups of learners. Second, medical learns' clinical judgement scores from each instructional method will be presented.

SVT Knowledge Acquisition

This study utilized a pre-posttest design to determine if there were knowledge gains on SVT patient treatment following the instructional methodologies. The pretest and posttest had different questions but measured the same constructs (see Appendix C & I) and were created by two experienced nurse practitioners. Concurrent validity was established by calibrating it against existing measures. This was done for the pretest by calibrating it against existing measures by deriving the questions from the tachycardia practice tests on the CareerCert website which provides accredited online certification for healthcare professionals (CareerCert, 2020). For the posttest, validity and reliability were established by deriving the questions from the tachycardia practice tests on the National Health Care Provider Solutions (NHCPS) website which provides accredited online certification for healthcare professionals (NHCPS, 2020).

The researcher compared SVT pre-posttest scores for both the IVR experimental group and the traditional simulation control group (see Table 5.2). A paired sample *t*-test was conducted to compare the results of the pretest and the results of the posttest after the IVR intervention. There was a significant difference in the scores on the pretest ($M = 70$, $SD = 26.22$) and posttest ($M = 97.7$, $SD = 6.66$) for the IVR group; $t\ (8) = -3.12$, $p = 0.01$. A paired sample *t*-test was also conducted to compare the results of the pretest and the results of the posttest for the traditional simulation group. There was no significant difference in the scores on the pretest ($M = 73.67$, $SD = 22.43$) and posttest ($M = 83.33$, $SD = 17.67$) for the traditional simulation group; $t(9) = -1.06$, $p = 0.32$. These results suggest that the use of IVR instructional methodology significantly increased SVT knowledge acquisition skills, while SVT knowledge acquisition did not significantly increase for the traditional simulation group.

Table 5.2

Mean (SD) and Paired Sample t Tests of SVT Knowledge for IVR and Traditional Simulation Groups

	Pre $n = 9$		Post $n = 9$		Paired Samples *t test*	
	M	*SD*	*M*	*SD*	*t*	*p*
Experimental IVR group scores	70	26.22	97.7	6.66	-3.12	.01
Traditional simulation group scores	73.67	22.43	83.33	17.67	-1.06	.32

The researcher also wanted to compare the SVT posttest results of the IVR experimental group with the traditional simulation control group to see if there were any significant differences (see Table 5.3). An independent *t*-test was conducted to determine if a difference existed between the mean posttest scores of the experimental IVR group and the traditional simulation control group. There was statistical significance between the mean SVT posttest scores of the IVR group (M = 97.78, SD = 6.66) and the traditional simulation group (M = 83.33, SD = 17.67), $t(10) = -2.29$, $p = .044$. Levene's test indicated unequal variances (F = 11.48, p = .004), so degrees of freedom were adjusted from 16 to 10. The results suggest that using an IVR instructional delivery method significantly increases SVT knowledge acquisition when compared to traditional simulation as an instructional delivery method.

Table 5.3

Mean (SD) and Independent Sample t Tests of SVT Knowledge of IVR and Traditional Simulation Groups

	Experimental $n = 9$		Control $n = 9$		Independent Samples *t test*	
	M	*SD*	*M*	*SD*	*t*	*p*
SVT Posttest scores	97.78	6.66	83.33	17.67	-2.29	.044

When conducting the independent *t*-test, the results indicated a failure to meet the normality assumption for the test. This was because the distribution of means between both samples was not normal as there was much greater differences in mean scores from pretest to posttest in the experimental group than there were in the control group. Therefore, the researcher conducted a Mann-Whitney *test* on the SVT posttest scores (see Table 5.4) because it is a non-parametric test that is used to compare means when the dependent variable is not normally distributed. Results of the test indicated that the SVT posttest scores were significantly greater for the IVR experimental group (*Mdn* = 100) compared to the traditional simulation control group (*Mdn* = 75), $U = 20$, $p = .03$, $r = .51$. The results suggest that using an IVR instructional delivery method significantly increases SVT knowledge acquisition when compared to traditional simulation as an instructional delivery method.

Table 5.4

Median, effective size and Mann-Whitney U Test of SVT Knowledge of IVR and Traditional Simulation Groups

	Experimental $n = 9$	Control $n = 9$	Mann-Whitney *U test*		
	Mdn	*Mdn*	*U*	*p*	*r*
SVT Posttest scores	100	75	20	.03	.51

Clinical Judgement

A nurse's clinical judgement skills when assessing and caring for patients is very critical to high quality healthcare (Yang, Thompson, & Bland, 2012). In order to test the participants on their clinical judgement skills during SVT patient assessment and treatment, the researcher had two trained nurse practitioners score the LCJR (see Appendix A) during the nursing students' participation in the SVT scenario of the intervention. The researcher calculated the rubric scores for both the experimental and the control group.

Experimental group. The LCJR measures four dimensions of clinical judgement. These are (a) effective noticing, (b) effective interpreting, (c) effective responding, and (d) effective reflecting. These dimensions are measured by four levels on the rating scale. These four levels are (a) beginning, (b) developing, (c) accomplished, and (d) exemplary. Each criterion in the dimension is measured using this scale for a total of 11 criteria. In an analysis of descriptive statistics for the experimental group, it appears that the participants were on the upper end of the developing scale for all dimensions (see Table 5.5). This suggests that participants in the experimental group are still developing their clinical judgement skills as observed during their SVT patient management in an immersive virtual reality scenario.

Table 5.5

Mean (SD) of the Lasater Clinical Judgement Rubric for the Experimental IVR Group

	n	M	SD
Noticing	9	2.74	0.595
Interpreting	9	2.72	0.565
Responding	9	2.58	0.819
Reflecting	9	2.72	0.618
Critical Thinking (Total Rubric)	9	2.66	0.505

Control group. The control group was observed during their traditional simulation scenario for treating an SVT patient and assessed by a trained nurse practitioner using the LCJR. Descriptive statistics were analyzed for the control group and the results suggest that the participants were also at the upper end of the developing scale for all dimensions except for one (see Table 5.6). For the noticing dimension, the participants in the control group were at the accomplished level of the scale. This indicates that the students in the control group are at the developing stage for clinical judgement on most dimensions and are overall at the accomplished stage for effective noticing which involves focused observation, recognizing deviations from expected patterns, and information seeking.

Table 5.6

Mean (SD) of the Lasater Clinical Judgement Rubric for the Control Traditional Simulation Group

	n	M	SD
Noticing	9	3.03	0.388

Table 5.6 (continued)

Interpreting	9	2.55	0.463
Responding	9	2.91	0.330
Reflecting	9	2.83	0.433
Critical Thinking (Total Rubric)	9	2.86	0.324

Experimental and control. The researcher also wanted to see if scores on the LCJR were significantly different from each other on all dimensions of the rubric. The researcher conducted an independent *t*-test to compare mean scores between the two groups (see Table 5.7). The results suggest that there was no statistically significant difference between the experimental and control groups on their clinical judgement skills as measured by the LCJR. Levene's test indicated unequal variances for the responding dimension ($F = 6.25$, $p = .02$), so degrees of freedom were adjusted from 16 to 10.9 for this dimension. This was because there was a statistically significant variance between the two groups on the LCJR.

Table 5.7

Mean (SD) and Independent Sample t Tests of Critical Thinking Scores on the LCJR

	Experimental $n = 9$		Control $n = 9$		Independent Samples *t*-test	
	M	*SD*	*M*	*SD*	*t*	*p*
Noticing	2.74	0.595	3.00	0.407	1.08	0.29
Interpreting	2.58	0.819	2.88	0.356	1.02	0.32
Responding	2.72	0.565	2.66	0.433	-0.23	0.81
Reflecting	2.72	0.618	2.77	0.440	0.22	0.82
Critical Thinking (Total Rubric)	2.65	0.505	2.86	0.324	1.05	0.30

Satisfaction and Self-Confidence in Learning

Participants in both the experimental and control groups completed the Satisfaction and Self-Confidence in Learning Questionnaire (SSLQ) (See Appendix B) after their SVT patient simulation. The questionnaire is a series of statements on participants' personal attitudes toward the instruction they received. The instrument has two subscales, a satisfaction scale (five questions) and a confidence subscale (eight questions). The SSLQ uses a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) for the students to indicate their level of agreement with each statement. Both groups were analyzed independently and together. First, this section will present how the experimental group scored on the SSLQ. Next, will describe how the control group scored on the SSLQ for traditional simulation instructional delivery. Finally, both groups will be compared to see if there were differences in perceived satisfaction and self-confidence between the two instructional methodologies.

Satisfaction and Self-Confidence in the Experimental Group

The experimental group completed the SSLQ after they had completed the SVT scenario and had finished the posttest. The researcher analyzed the descriptive statistics of the SSLQ (see Table 5.8) and the results indicated that participants agreed to positive statements about satisfaction (M = 4.44, SD = 0.480) and also agreed to positive statements about confidence (M = 4.49, SD = 0.401). Participants in the experimental group also scored high on the total scale measurement (M = 4.47, SD = 0.419). This suggests that the experimental group was satisfied with the IVR instructional delivery method and exhibited self-confidence during the scenario.

Table 5.8

Mean (SD) of the SSLQ for the Experimental IVR Group

	n	M	SD
Satisfaction	9	4.44	0.480
Confidence	9	4.49	0.401
Total Scale	9	4.47	0..419

Satisfaction and Self-Confidence in the Control Group

The control group also completed the SSLQ after they had completed the SVT scenario in the traditional simulation lab and had finished the posttest. The researcher analyzed the descriptive statistics of the SSLQ (see Table 5.9) and the results indicated that participants agreed to positive statements about satisfaction ($M = 4.12$, $SD = 0.453$) and also agreed to positive statements about confidence ($M = 4.13$, $SD = 0.539$). Participants in the control group also scored high on the total scale measurement ($M = 4.14$, $SD = 0.454$). This suggests that the control group was satisfied with the traditional simulation instructional delivery method and exhibited self-confidence during the scenario. This is in line with other studies that have measured satisfaction and self-confidence in traditional simulation lab instruction (Tosterud, Hedelin, & Hall-Lord, 2013).

Table 5.8

Mean (SD) of the SSLQ for the Control Group

	n	M	SD
Satisfaction	9	4.12	0.453
Confidence	9	4.13	0.539
Total Scale	9	4.14	0..454

Satisfaction and Self-Confidence Group Comparison

The researcher also wanted to see if there were any statistically significant differences between the experimental and control groups on the SSLQ. A Mann-Whitney *test* was selected as the appropriate test for the ordinal data (see Table 5.9). Results of the test indicated that the satisfaction scores were not significantly greater for the IVR experimental group (*Mdn* = 4.50) compared to the traditional simulation control group (*Mdn* = 4.25), $U = 24$, $p = 0.14$, $r = .35$. There was also no significant difference between confidence scores for the experimental group (*Mdn* = 4.60) compared to the traditional simulation group (*Mdn* = 4), $U = 25$, $p = 0.17$, $r = .32$. Likewise, scores on the total scale had no significant differences between the experimental group (*Mdn* = 4.56) and the traditional simulation group (*Mdn* = 4.11), $U = 23$, $p = 0.11$, $r = .38$. The results suggest that using an IVR instructional delivery method is satisfying to both groups and participants exhibit self-confidence in learning, but there are no statistically significant differences between their experiences.

Table 5.9

Median, effective size and Mann-Whitney U Test of SSLQ Scores for IVR and Traditional Simulation Groups

	Experimental $n = 9$	Control $n = 9$	Mann-Whitney *U test*		
	Mdn	*Mdn*	*U*	*p*	*r*
Satisfaction	4.50	4.25	24	.14	.35
Confidence	4.60	4.00	25	.17	.32
Total Scale	4.56	4.11	23	.11	.38

Qualitative Analysis of Satisfaction with the IVR Instructional Delivery Method

The SSLQ provided quantitative data and the results suggested that the experimental group was satisfied with the IVR instructional delivery method. The researcher also wanted to investigate qualitative data on the participants' experience with the IVR delivery method. Semi-structured interviews were conducted after the IVR participants completed the SVT scenario using the IVR instructional delivery method. The interviews were analyzed through inductive coding and several key concepts emerged (see Figure 5.2). This section will discuss the experimental group's experience with the IVR instructional delivery method by examining the emergent concepts of enjoyment, educational value, and repetitive practice.

Enjoyment

Participants in the IVR group were asked questions about their experience with the IVR instructional delivery method. When asked what the experience was like, Participant 1 answered "I like this one [IVR compared to traditional simulation] better because it really gets you into the game…I think it is a very good learning experience which I really enjoyed". Participant 6 also expressed enjoyment by responding "it was kind of fun to find them [interactive hotspots] too. It was really cool how they [information screens] popped up, it was really neat". Participant 1 also enjoyed the process of clicking on the interactive objects. "I thought it was really cool. I've never done anything like that before—being able to click on all the things was also awesome."

In addition to enjoyment of the IVR method itself, some of the participants expressed that they enjoyed the IVR instructional delivery method more than other instructional methods they had used. Participant 2 mentioned that "it was definitely different than what we are used to, so I think that being hands-on like that was really good. And also it made you feel like you were there with the patient. So yeah, I really enjoyed it". Participant 1 expressed that the IVR delivery method was better than a traditional simulation lab delivery method:

> It's definitely one of the cooler things. You really get the critical thinking and real-time [aspect] rather than you're just sitting there, drawing-it-out thinking. Compared to real clinic or sim-lab I would say this is one of the cooler things just because it is real-time and you really are by yourself trying to process things as you would in any nursing situation.

Participant 6 also enjoyed the IVR method above traditional simulation lab instruction because it was an alternative to the pressure of being at the physical location:

> It was really cool and I felt like almost a little less pressure than I would if I were actually in the sim lab. It's just nice to do it that way and not like physically be there. It just felt like a better practice…like I would never forget SVT.

These statements by the participants indicate that not only were they satisfied with the IVR instructional delivery method as measured on the SSLQ, but that they enjoyed it as well.

Educational Value

SBME has been shown to be an effective means for medical students, which is a category that includes nursing students, to learn and acquire clinical skills (Cook, Brydges, Zendejas, Hamstra, & Hatala, 2013; Issenberg, Mcgaghie, Petrusa, Gordon, & Scalese, 2005; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011). The researcher wanted to see if delivering simulation-based medical and nursing????? education via an IVR delivery method to nursing students would be as equally educational as traditional SIM lab trainings. In addition to analyzing pre-posttest scores and clinical judgement, the researcher analyzed answers to a semi-structured interview to see if the participants perceived the IVR delivery method to be educational. When asked if the SVT scenario in IVR was beneficial, participant 7 said it was educational because "the students aren't just reading out of the textbook…it's kind of putting you through the real thing but it's like the real experience". Participant 2 reflected on how it was educationally beneficial to developing critical thinking skills, saying:

> You had to know your medications to know what to give first. And you actually had to read through the MAR [medication administration record] on the computer because it said starting dose was 6 milligrams, and if it doesn't work, start something else.

When asked if they felt like the IVR scenario was educational, participant 1 said "Oh absolutely, yeah I really do especially because you guys could see everything." The participant was referring to the ability of the nurse practitioner to watch what the participant was doing within the IVR scenario in real-time. This capability allowed the nurse practitioner to give the students feedback on their performance during the debriefing session. Participant 9 said that it was educational because "you are making sure to monitor the vitals with the respirators and the heart rate…then watching rhythm and stuff—that really important while doing assessments." These statements suggest that the participants felt the IVR instructional delivery method was educational and beneficial for their development as nursing students. One participant remarked that having this instructional delivery method as an option would have influenced her choice of nursing school. When asked a follow-up about the educational value, participant 6 said:

> Very beneficial. I think that's amazing if they [the nursing program] were to have that here. I would tell my sister she needs to come here because she's going to nursing school somewhere. I would say 'go to Midland'…I feel like it would just enhance the learning process of everything.

Such statements suggest that there would be a value-added to including IVR instructional methodology to a nursing program.

Repetitive Practice

One of the main features of SBME that leads to effective learning is repetitive practice (Issenberg et al., 2005). One critique of SBME is that it does not allow students sufficient opportunities for repetitive practice (Price, Price, Pratt, Collins, & McDonald, 2010). For students to practice their skills, they need to be able to schedule time with the simulators and have access to equipment (Dieckmann et al., 2012). However, lack of time, an insufficient number of manikins, and limited simulation space prevent students from opportunities of repetitive practice (Al-Ghareeb & Cooper, 2016). The participants enjoyed the IVR instructional delivery method and found it to have educational value. The researcher also wanted to see if the participants felt that the IVR instructional delivery method would afford them opportunities for repetitive practice. When asked to provide their insights on the IVR instructional method being offered to students, Participant 8 provided the following insights:

> That would be insane! That would be awesome! Because we only get to go to sim lab a couple times and it's a very organized event. Like you have to be there at a certain time, so doing this would take the stress off of some of that. So if you're just sitting at home you'll have something where you can practice the scenario. It would be a great idea!

Participant 5 recognized that IVR would provide opportunities for repetitive practice by saying it "would help definitely. And once you keep doing it [IVR] you'd get use to it…you can do so many different situations." Participant 2 also acknowledged the limited ability to practice in a traditional simulation lab and that the IVR delivery method would help with repetitive practice:

> A lot of times we're in simulation and we're only allowed to do it once. But say if we get the VR, we can practice at home, or if we are on campus we can just go and even with the classmates we can even teach or learn as a group thing.

Participant 6 remarked that being able to practice simulation in an IVR environment would make them less anxious about simulation lab. "It would make it so much better because as students we feel like thrown into it [simulation lab] in as sense, but I feel like it [IVR] would definitely ease anxiety—not knowing what to do." These statements suggest that participants felt IVR would be able to provide them with opportunities for repetitive practice, which could lead to less anxiety and better preparedness when in simulation lab for assessment or when they are on their clinicals.

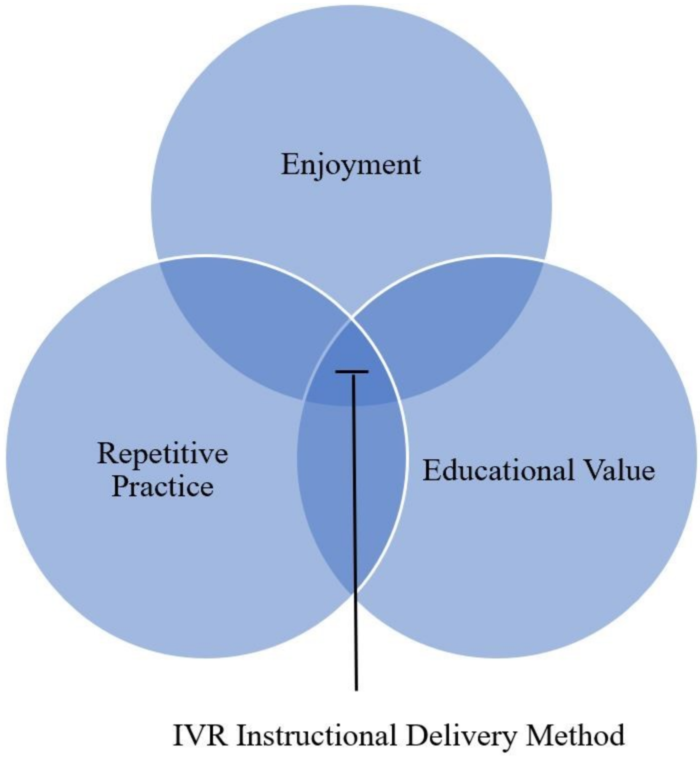

Figure 5.2. IVR instructional delivery themes.

Discussion

The researcher designed an intervention to test the hypothesis that students who participate in a simulation-based medical education scenario via an immersive virtual reality delivery method would have similar results in knowledge acquisition, satisfaction, and self-confidence compared to students receiving the same instruction via a traditional simulation lab methodology. This section will review and interpret the findings within the context of the literature and seek to explain phenomenon. Both the process evaluation outcomes and the outcome evaluation research questions will provide the structure for this section.

Orientation Time (PERQ1)

Fidelity of implementation is comprised of reach, dose, dose received and fidelity (Linnan & Steckler, 2002). Concerning PERQ1, fidelity to program implementation considered whether learners felt that a 20-minute orientation session with the IVR equipment was enough time for them to become familiar with its use for the subsequent instructional session. All of the IVR nursing students (n=9) participated in the orientation session which provided 20 minutes for them to adjust to the IVR equipment and navigate the IVR environment. The orientation session followed an orientation protocol that covered attendance, introduction to IVR, the equipment and the intervention procedures.

Research Design Alignment (PERQ2)

Quantitative analysis of the attendance tracker and the orientation session time showed that all of the students participated, and they felt like they were ready to proceed with the intervention. Even though the participants were provided 20 minutes to orient themselves, the participants were ready within an average of approximately 5 minutes. This was one quarter of the time that the researcher anticipated they would need. This indicates that the IVR equipment is easy to set-up, adjust to the user, and is intuitive enough that someone who has never been exposed to IVR can begin manipulating the environment fairly quickly. This finding is in line with other studies on IVR in education (Lau & Lee, 2015; Passig, Tzuriel, & Eshel-Kedmi, 2016).

The intervention was in alignment with the research design. This was based on analysis of the orientation session protocol checklist and the tracking of technical issues throughout the intervention. Checklists were completed and 100% of the items were completed for all IVR participants. This ensured that each participant was treated in the same way as the research design intended. The only deviation from the research design was due to a technical issue. The Wi-Fi at the hospital would not allow the Oculus Go to connect, which was necessary to sync with the iPad and display the SVT instructional content. As a consequence, the intended context of the research design had to change.

The context is defined as the environment in which the intervention takes place (Baranowski & Stables, 2002). The context for the IVR intervention, including the orientation session, was intended to be held at Methodist Fremont Health's simulation lab. However, because of the technical issue, the IVR portion of the intervention had to be relocated to the campus of Midland University. Despite this change in context, other contextual elements for the IVR sessions including a well-lit room with a display monitor, an iPad, an Oculus Go virtual reality headset and controller were present and aligned with the original research design. It has been determined that despite the venue change for the IVR group, the context was implemented with fidelity which resulted in a successful orientation session where all participants were oriented to the IVR equipment and scenario in less time than what had originally been planned.

Level of Participation (PERQ3)

The nursing students' participation in the orientation and process was a key indicator in determining if the orientation and session is successful. The participation provided valuable feedback on dose (Linnan & Steckler, 2002). For the orientation session there was a goal that 90% of the participants would feel that the orientation protocol with an allotted time of 20 minutes, in this case the dose, helped them understand how to use the IVR equipment and successfully navigate the virtual environment. One of the nine participants indicated that they wanted more time during the orientation session, so the design fell short of this goal (88%). This was a retrospective insight for the student, as they elected to continue with the intervention after approximately 7 minutes of orientation. In addition, the software allowed the researcher and nurse practitioner to observe the participants' interactions with the virtual environment and understand user mistakes and challenges navigating the activities as well as their level of participation throughout the IVR scenario. It has been determined that because the orientation session was aligned with the research design, the participants had an easier transition from the orientation session to the instructional session and were thus able to have a high level of participation.

This high level of participation was confirmed through responses to the semi-structured interview. Qualitative data were analyzed for participant responsiveness (Dusenbury, Brannigan, Falco, & Hansen, 2003) and gathered after each debriefing session through audio recordings of semi-structured interviews that were administered and then transcribed by the researcher. The interviews were designed to elicit participant responses on what they thought about the orientation session as well as how they perceived their participation in the SVT scenario. The answers that the students gave about their experiences indicated a high level of participation because they showed that the students were engaged in the activities and the content of the SVT scenario. In addition, the researcher looked at another aspect of participant responsiveness by investigating whether the students would recommend the IVR instructional delivery method to others (Hansen, 1996). The participants expressed enthusiasm for the IVR scenario and would recommend that instructional methodology to others in the nursing program. One participant even said that having such an instructional method as part of the nursing program would influence choice in schools. Several participants asked the researcher if this would be part of the curriculum next semester. Thus, the mixed methods research design suggested both quantitatively and qualitatively that there was a high-level participation in the IVR experimental group.

Clinical Judgment and SVT Skills Acquisition (OERQ1)

The first outcome evaluation research question investigated SVT skills acquisition and clinical judgement. Clinical judgement is an especially important skill in nursing and has received recent attention. The National Council State Boards of Nursing's Next Generation National Council Licensure Examination (NCLEX) has recently made changes to its test item style to emphasize clinical judgement (Sherrill, 2020). The researcher designed the intervention so that clinical judgement could be assessed for both the experimental and control groups. The groups were observed by trained nurse practitioners during the intervention and clinical judgement skills were scored on a reliable and valid instrument (Adamson, Gubrud, Sideras, & Lasater, 2012) called the Lasater clinical judgement rubric (Lasater, 2007). The scores indicated that both groups were in the developing stage of their clinical judgement for SVT patient assessment and management. This is comparable to other studies that have used the LCJR to score critical thinking in senior-level nursing students (Cazzell, & Anderson, 2016; Fedko, & Dreifuerst, 2017). Because there were no significant differences in LCJR scores between groups, it seems that the IVR instructional methodology used in this intervention is a valid way to observe clinical judgement in nursing students. Simulation labs have been a proven training methodology (Cook, Brydges, Zendejas, Hamstra, & Hatala, 2013) therefore the similarity between the control and experimental groups on their LCJR scores provide an answer to OERQ1 that clinical judgement can be assessed in an IVR environment.

However, it should be noted that for the noticing dimension, the participants in the control group were at the accomplished level of the scale. This indicates that the students in the control group are at the developing stage for clinical judgement on most dimensions and are overall at the accomplished stage for effective noticing which involves focused observation, recognizing deviations from expected patterns, and information seeking. The researcher speculates that this difference in scores may have resulted from the IVR group having to navigate an environment that used a haptic controller to investigate invisible hotspots with more information about the virtual patient and his management. The control group, having experienced simulation lab before, would not have had this extra cognitive distraction, and therefore were able to score higher on the noticing dimension because they would have had more focused observation during the SVT scenario. Elements in the IVR scenario may be adjusted in future iterations in order for the IVR group to overcome this disadvantage. For example, visible hotspots and verbal communication from the virtual patient might lead to improved scores in the noticing dimension.

The other investigation for the delivery method was SVT knowledge acquisition as measured by a pre-posttest design. Both groups took a pretest, participated in the intervention, and then took a posttest on SVT to determine if there was a change in knowledge acquisition between the two groups. Items on the posttest were different from that of the pretest but were designed and validated by two nurse practitioners to test SVT knowledge acquisition (see Appendices H & I). The reason that items on the posttest were worded and presented differently from the pretest was in order to mitigate any threats to validity from testing effects. Thus, the posttest employed item response theory so that tests were different but were still measuring the same SVT assessment construct (Shadish, Cook, & Campbell, 2002). The results indicated that the IVR experimental group improved their pretest scores significantly, and the change in posttest scores was significantly greater than that of the control group that received instruction from a traditional simulation lab. This was an unexpected result. Traditional simulation lab instruction has been shown in the literature to increase knowledge acquisition in various medical subjects (Datta, Upadhyay, & Jaideep, 2012; Fisher & Walker, 2013; Khunger & Kathuria, 2016;

Lewis, Strachan, & Smith, 2012). If the IVR group had scored similarly to the control group, then the case could be made that an IVR instructional delivery method might be just as effective at knowledge acquisition as traditional simulation lab instruction. However, because the scores of the IVR group were statistically more significant than the control group, the implication is that IVR may be better at increasing knowledge acquisition in nursing students than the traditional methodology.

Confidence in Learning (OERQ2)

Patient safety is a critical concern in the healthcare industry and one of the factors that affects patient safety is the confidence that nurses have in caring for a patient (Usher et al., 2017). Thus, one of the goals of medical education is to increase medical learners' confidence through exposure to clinical scenarios (Patel, Yoskowitz, & Arocha, 2009). An effective way to accomplish this, while keeping the learners and patients safe, is through the use of medical simulations (Arora, Hull, Fitzpatrick, Sevdalis, & Birnbach, 2015). The researcher wanted to see how confident the participants in both experimental and control groups felt about their patient assessment management skills after participating in a simulation. Their self-reported confidence was measured by the Student Satisfaction and Self-Confidence in Learning Questionnaire (SSLQ) with valid measures on both scales established through a multistate panel of medical simulation specialists (Butler, Dawn, & Brady, 2009; Smith & Roehrs, 2009). The results indicated that students in both groups felt confident in managing and assessing SVT patients after the instructional methodologies. Because there were no significant differences between the groups, it appears that both simulation succeeding in establishing confidence amongst the students. Though there was no statistically significant correlation between the confidence of the students and their performance on the posttest, it is assumed that increased confidence and posttest scores are interconnected. In fact, none of the students in both groups disagreed with any of the statements about confidence on the SSLQ. This is similar to studies that have shown confidence among students that participate in educational simulation activities (Curan et al., 2015; Donkers, Bednarek, Downey, & Ennulat, 2015; Sobocan & Klemenc-Ketis, 2016). This implies that students who participate in IVR instructional methodology might obtain the same results in confidence that traditional simulation activities provide, thus increasing patient safety when they become practitioners.

Satisfaction in Learning (OERQ3)

One aspect of simulation-based medical education (SBME) is fidelity. When researchers and designers talk about fidelity in terms of simulation, they are referring to “the degree to which the trainee perceives the simulation to be authentic or real by 'suspension of disbelief'" (Kalaniti & Campbell, 2015, p. 43). A study by Curran et al. (2015) found that the absence of fidelity led to significantly lower scores of students’ satisfaction ratings. Part of the research design and selection of IVR as a delivery method is that this modality is able to simulate the real world (Gokeler et al. 2016; Lorenz et al., 2015). Thus, the researcher hypothesized that the participants in the IVR group would self-report satisfaction with the instructional delivery method. The analysis of the SSLQ results showed that both groups were satisfied with the instructional delivery methods and none of the participants in the IVR group disagreed with any of the statements about satisfaction on the SSLQ.

The other metric for understanding the IVR participants’ satisfaction with the instructional delivery method was results from the semi-structured interviews. The researcher asked questions and analyzed answers about satisfaction that highlighted three themes: enjoyment, educational value, and repetitive practice. All three of these concepts supported the participants' perceptions of satisfaction with the IVR delivery method. Enjoyment was not a surprising finding as there have been studies that show when users engage with a virtual environment, they enjoy the experience (Lau & Lee, 2015; Nevin et al., 2014). This enjoyment is crucial to engagement and in turn affects the educational value of the delivery method. All three concepts are reciprocal elements. The participants also recognized the educational value of the delivery method, which was also in line with other studies (De Gloria, Bellotti, Berta, & Lavagnino, 2014; Graafland, Schraagen, & Schijven, 2012).

Because the participants perceived the IVR method as educationally valuable, they are more likely to engage in repetitive practice with the content, which in the researcher's opinion, is the most valuable and significant finding in the study. One of the main impetuses for investigating an IVR intervention was that SBME, while effective, requires deliberate, repetitive practice to have successful educational outcomes (Bosse et al., 2015; Chee, 2014; Motola et al., 2013). Unfortunately, students are not afforded the opportunities for repetitive practice of their skills within a simulation lab (Price, Price, Pratt, Collins, & McDonald, 2010). This is because students have difficulty scheduling time with the simulators and equipment (Dieckmann et al., 2012). Students also have to find time for qualified personnel to run the simulations and oversee the manikin as well as the instruction. However, lack of time, an insufficient number of manikins, and limited simulation space prevent them from doing so (Al-Ghareeb & Cooper, 2016). Therefore, providing students with an educational solution that can be used for repetitive practice is of paramount importance.

The Oculus Go IVR headset used in this study is wireless, portable, and affordable (Hoffman et al., 2014; Morris, Louw, & Crous, 2010; Standen et al., 2015). The total material costs to the researcher to develop the IVR scenario, including hardware and software, was approximately $1000. The cost does not include the researcher's time and expertise in designing the scenario, nor the personnel that helped to program the simulation lab scenario. Therefore, it should be noted that in order to replicate this study, the additional cost of personnel to design, create, and implement the scenario would need to be factored in. Another important note about the cost is that there are too many unknowns to draw a fair cost comparison between IVR and the traditional simulation lab. The equipment and software used in this study created a rather low-fidelity experience, when talking about the realism between IVR and traditional simulation. There is more expensive hardware and software and creating a truly immversive experience for a student could certainly cost much more than the total dollar amount in this study. However, the cost to operate a simulation skills lab for one year is approximately $700,000 (Miller, 2017) not including the cost of the simulation mannikins themselves, which can cost up to $80,000 per mannikin (Gaumard, 2020). In contrast, the IVR delivery method used in this study was astoundingly less, and certainly is a factor when considering IVR use as a supplement to traditional SBME instruction, or in the case of an institution that does not have access to a simulation lab, it might serve a similar function. The IVR delivery method also provides learners with the opportunity to practice their critical thinking skills at a time and place that is convenient to their schedule, perhaps even at home.

The participants expressed during the semi-structured interview that the IVR instructional delivery method would provide them the opportunity for repetitive practice, something that they expressed was not available to them with traditional simulation. Participant 2 was especially enthusiastic, saying that "if we get the VR, we can practice at home". This is a game-changing application that help students gain the crucial skills and self-confidence that will translate into their performance during clinicals, certification tests and ultimately for educating and preparing students for work in a clinical setting (Ahmed, Al-Mously, Al-Senani, Zafar, & Ahmed, 2016).

Role of the Researcher

It should be noted that the professional expertise of the researcher was instrumental to the success of this intervention study. The researcher has an educational and professional background in educational technology and a specific interest in using immersive virtual reality for educational purposes. The researcher used this knowledge to construct and design the immersive virtual reality scenario that was used in the study as well as the technical components involved in making the student interactions in the IVR environment visible to the trained observers. While the researcher did not influence the participants in any way, the successful outcomes, especially concerning the process evaluation, may have been a result of the researcher's expertise and abilities in these technical areas.

For example, when creating the orientation session for the IVR scenario, the researcher placed participants in a virtual beach environment. As mentioned previously, this was an incidental finding during the semi-structured interview. This tranquil scene might have affected the participant outcomes in the IVR scenario by reducing participant stress prior to the intervention. Future studies need to investigate the pre-intervention scenario for both control group and experimental group to see if a relaxing scene may affect the performance in both groups.

Prior Knowledge

Another factor that may have influenced outcome results is the prior exposure to simulation lab. Though the participants did not have prior exposure to an SVT curriculum, they did have prior exposure to a simulation lab environment. This may have benefited the control group, because they participated in a simulation lab environment in which they already had familiarity. The experimental group, by contrast, had not had exposure to the IVR environment, which may have affected their performance in the intervention.

Limitations

There are several limitations of this research. These limitations include a small sample size, the issue of time, the IVR software that was selected for SVT scenario creation, and the instruments that were selected for the research design.

The original research design estimated an effect size of participants (n = 42). Despite a pool of approximately 50 senior-level nursing students and multiple recruitment attempts, the researcher was only able to include 18 participants in the intervention. This may have also been an issue of timing, as many of the students were overwhelmed with other schoolwork and obligations. Distance may have also been a factor, as one of the nursing schools that was recruited was approximately 30 miles from the research site. Another limitation with the sample size is that those that volunteered may have done so because they like simulation lab or had an interest in experiencing IVR, which may have skewed the results.

Time was also a limiting factor. The students participated in a one-time SVT scenario intervention and for many it was their first time experiencing IVR. Ideally the intervention would have been extended over the course of the semester and imbedded into the nursing curriculum so that more longitudinal data could be gathered.

Another limitation was the software that was used for creating the IVR SVT scenario. The software itself had several limitations. One is that it would not allow branch logic—this feature would have been helpful because it would have allowed for the scenario to change in real-time based on participants' actions. Another limitation of the software was the lack of voice recognition capabilities. This would have increased the participant's ability to communicate with the SVT patient and is something that the participants themselves noticed as a limitation during the semi-structured interviews. Because of these limitations, the IVR instructional method was not identical to the traditional simulation and may have affected results on the LCJR. For example, because the simulated patient in the IVR delivery method could not respond to questions, students may have felt reluctant to use their communication skills to the fullest extent like they would in a traditional simulation lab scenario, where a human-controlled manikin could respond to students' inquiries.

Finally, the instruments used for the design may have affected the results. The SSLQ is a self-reporting instrument used to measure satisfaction and self-confidence. Also, the pre-posttests, though created by experienced nurse educators and derived from existing curriculum, were new instruments used to assess SVT knowledge acquisition. The LCJR is a valid and reliable instrument but it is subject to measurement bias which may have affected clinical judgement outcomes.

Implications for Research

This intervention has the following implications for research. First, future research should consider a larger sample size. The larger sample size should also include participants from different nursing schools so that findings may be generalizable. It would also be beneficial to get a large enough sample size that participant demographics can help inform the data. Characteristics such as gender, video-game use, and age may be taken into consideration to see how they might affect the results.

Second, future research should take advantage of the ever-changing software and technology that comprises the IVR world. Software with more extensive tracking analytics and educational features would improve research design and provide greater insights. The IVR headsets are also becoming more powerful, more portable, and more affordable. As the line between reality and virtual reality continue to blur, future research should take advantage of the latest and greatest in IVR hardware to continue to test its educational capabilities.

Finally, future research should consider a longitudinal study where an RCT design could track students over an entire semester of curriculum. IVR instructional scenarios could be created that span a wider array of medical scenarios. When comparing these students to a control group that goes through traditional simulation lab curriculum over a greater period of time, more robust data can be created. This would also allow for students in the IVR group to take the equipment home with them to engage in deliberate, repetitive practice which would provide valuable data on knowledge acquisition and self-confidence between the two groups.

Implications for Practice

Although this research study had a small sample size, it provided some insights into how a nursing curriculum might be supplemented to improve student outcomes. SBME has been researched as an effective means for medical students to learn and acquire clinical skills (Cook, Brydges, Zendejas, Hamstra, & Hatala, 2013; Issenberg, Mcgaghie, Petrusa, Gordon, & Scalese, 2005; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011). However, simulation labs are not always accessible, and some institutions do not even have simulation labs available for their students. A needs assessment found that faculty and students both felt they did not have enough time to facilitate and participate in repetitive practice of clinical skills (Miller, 2017). This study elucidated a way that nursing schools can help students engage in deliberate, repetitive practice by using IVR as a supplement to traditional simulation lab instruction. The satisfaction, self-confidence, and clinical judgement scores of the IVR students were similar to those in the traditional simulation lab and knowledge acquisition was greater. This implies that students could use IVR in the comfort of their homes or campus dorms to practice the skills necessary to perform well on NCLEX exams and ultimately better serve their future patients.

Conclusion

In revisiting their seminal article “A Critical Review of Simulation-Based Medical Education Research: 2003 – 2009,” the authors said that “today’s academic medical community educates twenty-first century physicians using nineteenth century thinking, methods and technology” (McGaghie, Issenberg, Petrusa, & Scalese, 2016, p. 986). The authors were lamenting that medical education was still largely didactic and expected nurses and physicians to take expert care of patients despite knowledge and skill deficits. These deficits resulted from reliance on tests and little consideration for rigorous assessment and evaluation of acquired clinical skills. Simulation-based medical education provided opportunities for students to practice clinical judgement and procedural skills in a way that gave them hands-on experience while preserving patient safety.

This study has shown the accessibility problems associated with SBME, and though SBME was a major step in the advancement of medical education, it is time for another evolution. As IVR technology continues to improve, it will provide students with opportunities to practice and learn medicine in ways that we have not yet been able to deliver. This author believes that IVR is truly the future of medical education. The technology is accessible, visceral, and immediate, providing a vehicle to acquire medical knowledge and skills. Maybe it will help students not only discover something about their patients but discover something about themselves.

The student is to collect and evaluate facts.

The facts are locked up in the patient.

-Abraham Flexner

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APPENDIX A

Lasater Clinical Judgement Rubric (LCJR)

Lasater Clinical Judgment Rubric

Dimension	Exemplary	Accomplished	Developing	Beginning
Effective noticing involves:				
Focused observation	Focuses observation appropriately; regularly observes and monitors a wide variety of objective and subjective data to uncover any useful information	Regularly observes and monitors a variety of data, including both subjective and objective; most useful information is noticed; may miss the most subtle signs	Attempts to monitor a variety of subjective and objective data but is overwhelmed by the array of data; focuses on the most obvious data, missing some important information	Confused by the clinical situation and the amount and kind of data; observation is not organized and important data are missed, and/or assessment errors are made
Recognizing deviations from expected patterns	Recognizes subtle patterns and deviations from expected patterns in data and uses these to guide the assessment	Recognizes most obvious patterns and deviations in data and uses these to continually assess	Identifies obvious patterns and deviations, missing some important information; unsure how to continue the assessment	Focuses on one thing at a time and misses most patterns and deviations from expectations; misses opportunities to refine the assessment
Information seeking	Assertively seeks information to plan intervention: carefully collects useful subjective data from observing and interacting with the patient and family	Actively seeks subjective information about the patient's situation from the patient and family to support planning interventions; occasionally does not pursue important leads	Makes limited efforts to seek additional information from the patient and family; often seems not to know what information to seek and/or pursues unrelated information	Is ineffective in seeking information; relies mostly on objective data; has difficulty interacting with the patient and family and fails to collect important subjective data
Effective interpreting involves:				
Prioritizing data	Focuses on the most relevant and important data useful for explaining the patient's condition	Generally focuses on the most important data and seeks further relevant information but also may try to attend to less pertinent data	Makes an effort to prioritize data and focus on the most important, but also attends to less relevant or useful data	Has difficulty focusing and appears not to know which data are most important to the diagnosis; attempts to attend to all available data
Making sense of data	Even when facing complex, conflicting, or confusing data, is able to (a) note and make sense of patterns in the patient's data, (b) compare these with known patterns (from the nursing knowledge base, research, personal experience, and intuition), and (c) develop plans for interventions that can be justified in terms of their likelihood of success	In most situations, interprets the patient's data patterns and compares with known patterns to develop an intervention plan and accompanying rationale; the exceptions are rare or in complicated cases where it is appropriate to seek the guidance of a specialist or a more experienced nurse	In simple, common, or familiar situations, is able to compare the patient's data patterns with those known and to develop or explain intervention plans; has difficulty, however, with even moderately difficult data or situations that are within the expectations of students; inappropriately requires advice or assistance	Even in simple, common, or familiar situations, has difficulty interpreting or making sense of data; has trouble distinguishing among competing explanations and appropriate interventions, requiring assistance both in diagnosing the problem and developing an intervention
Effective responding involves:				
Calm, confident manner	Assumes responsibility; delegates team assignments; assesses patients and reassures them and their families	Generally displays leadership and confidence and is able to control or calm most situations; may show stress in particularly difficult or complex situations	Is tentative in the leader role; reassures patients and families in routine and relatively simple situations, but becomes stressed and disorganized easily	Except in simple and routine situations, is stressed and disorganized, lacks control, makes patients and families anxious or less able to cooperate

Lasater Clinical Judgment Rubric

Dimension	Exemplary	Accomplished	Developing	Beginning
Clear communication	Communicates effectively; explains interventions; calms and reassures patients and families; directs and involves team members, explaining and giving directions; checks for understanding	Generally communicates well; explains carefully to patients; gives clear directions to team; could be more effective in establishing rapport	Shows some communication ability (e.g., giving directions); communication with patients, families, and team members is only partly successful; displays caring but not competence	Has difficulty communicating; explanations are confusing; directions are unclear or contradictory; patients and families are made confused or anxious and are not reassured
Well-planned intervention/flexibility	Interventions are tailored for the individual patient; monitors patient progress closely and is able to adjust treatment as indicated by patient response	Develops interventions on the basis of relevant patient data; monitors progress regularly but does not expect to have to change treatments	Develops interventions on the basis of the most obvious data; monitors progress but is unable to make adjustments as indicated by the patient's response	Focuses on developing a single intervention, addressing a likely solution, but it may be vague, confusing, and/or incomplete; some monitoring may occur
Being skillful	Shows mastery of necessary nursing skills	Displays proficiency in the use of most nursing skills; could improve speed or accuracy	Is hesitant or ineffective in using nursing skills	Is unable to select and/ or perform nursing skills
Effective reflecting involves:				
Evaluation/self-analysis	Independently evaluates and analyzes personal clinical performance, noting decision points, elaborating alternatives, and accurately evaluating choices against alternatives	Evaluates and analyzes personal clinical performance with minimal prompting, primarily about major events or decisions; key decision points are identified, and alternatives are considered	Even when prompted, briefly verbalizes the most obvious evaluations; has difficulty imagining alternative choices; is self-protective in evaluating personal choices	Even prompted evaluations are brief, cursory, and not used to improve performance; justifies personal decisions and choices without evaluating them
Commitment to improvement	Demonstrates commitment to ongoing improvement; reflects on and critically evaluates nursing experiences; accurately identifies strengths and weaknesses and develops specific plans to eliminate weaknesses	Demonstrates a desire to improve nursing performance; reflects on and evaluates experiences; identifies strengths and weaknesses; could be more systematic in evaluating weaknesses	Demonstrates awareness of the need for ongoing improvement and makes some effort to learn from experience and improve performance but tends to state the obvious and needs external evaluation	Appears uninterested in improving performance or is unable to do so; rarely reflects; is uncritical of himself or herself or overly critical (given level of development); is unable to see flaws or need for improvement

APPENDIX B

Satisfaction and Self-Confidence in Learning Questionnaire

Student Satisfaction and Self-Confidence in Learning

Instructions: This questionnaire is a series of statements about your personal attitudes about the instruction you receive during your simulation activity. Each item represents a statement about your attitude toward your satisfaction with learning and self-confidence in obtaining the instruction you need. There are no right or wrong answers. You will probably agree with some of the statements and disagree with others. Please indicate your own personal feelings about each statement below by marking the numbers that best describe your attitude or beliefs. Please be truthful and describe your attitude as it really is, not what you would like for it to be. This is anonymous with the results being compiled as a group, not individually.

Mark:

1 = STRONGLY DISAGREE with the statement
2 = DISAGREE with the statement
3 = UNDECIDED - you neither agree or disagree with the statement
4 = AGREE with the statement

5 = STRONGLY AGREE with the statement

Satisfaction with Current Learning	SD	D	UN	A	SA
1. The teaching methods used in this simulation were helpful and effective.	O 1	O 2	O 3	O 4	O 5
2. The simulation provided me with a variety of learning materials and activities to promote my learning the medical surgical curriculum.	O 1	O 2	O 3	O 4	O 5
3. I enjoyed how my instructor taught the simulation.	O 1	O 2	O 3	O 4	O 5
4. The teaching materials used in this simulation were motivating and helped me to learn.	O 1	O 2	O 3	O 4	O 5
5. The way my instructor(s) taught the simulation was suitable to the way I learn.	O 1	O 2	O 3	O 4	O 5
Self-confidence in Learning	**SD**	**D**	**UN**	**A**	**SA**
6. I am confident that I am mastering the content of the simulation activity that my instructors presented to me.	O 1	O 2	O 3	O 4	O 5
7. I am confident that this simulation covered critical content necessary for the mastery of medical surgical curriculum.	O 1	O 2	O 3	O 4	O 5
8. I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting	O 1	O 2	O 3	O 4	O 5
9. My instructors used helpful resources to teach the simulation.	O 1	O 2	O 3	O 4	O 5
10. It is my responsibility as the student to learn what I need to know from this simulation activity.	O 1	O 2	O 3	O 4	O 5
11. I know how to get help when I do not understand the concepts covered in the simulation.	O 1	O 2	O 3	O 4	O 5
12. I know how to use simulation activities to learn critical aspects of these skills.	O 1	O 2	O 3	O 4	O 5
13. It is the instructor's responsibility to tell me what I need to learn of the simulation activity content during class time..	O 1	O 2	O 3	O 4	O 5

 Revised December 22, 2004

APPENDIX C

Pretest on SVT Knowledge

1. Tachycardia is defined as:
A. An arrhythmia with a rate greater than 150/min
B. An arrhythmia with a rate greater than 100/min
C. Any rhythm disorder with a heart rate less than 60/min
D. An organized rhythm without a pulse

2. Which drug is the preferred intervention for terminating supraventricular Tachycardia (SVT)?
A. Epinephrine
B. Amiodarone
C. Atropine
D. Adenosine

3. If SVT does not respond to vagal maneuvers, how much adenosine do you give:
A. 20mL rapid IV push
B. 12 mg rapid IV push
C. 6 mg IV push over 10 seconds
D. 6mg rapid IV push over 1 second

APPENDIX D

Semi-structured Interview Questions

Q1: What did you think about the amount of time given for the orientation?

Q2: What would you have done to improve the orientation?

Q3: What did you think of the immersive virtual reality experience?

Q4: What did you think about the educational value of the virtual reality experience?

Q5: Tell me your thoughts on this delivery method being able to facilitate repetitive practice.

Q6: How does this experience compare to other nursing instructional methods?

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APPENDIX E

Summary Matrices of Research Questions

Process Research Questions

PERQ1	Variable	Instrumentation	Data Source(s)	Data Collection Frequency	Data Analysis
	Medical learners' participation in orientation session	Focus group semi-structured interview responses during debriefing session	Students that participate in the orientation session	Once at the end of each instructional unit, total of 9 sessions.	Inductive thematic coding of semi-structured interview
	Orientation time	Spreadsheet to log orientation times of participants	Students that participate in the orientation session	Once at the end of each orientation session, total of 9 sessions.	Descriptive statistics of time taken

PERQ2	Variable	Instrumentation	Data Source(s)	Data Collection Frequency	Data Analysis
	Delivery of orientation session protocol	Orientation session protocol checklist	Researcher administering the orientation checklist	Once at the end of each orientation session, 9 sessions altogether	Quantitative analysis of orientation time and number of checklist requirements met
	Functionality of equipment	Spreadsheet to record and track equipment failures and software glitches Computer error logs	Researcher and software analytics	Constantly throughout equipment use during all sessions	Quantitative review of error logs and instances of equipment failure
PERQ3	Variable	Instrumentation	Data Source(s)	Data Collection Frequency	Data Analysis
	Medical learners'	Focus group semi-structured	Students that participate in	Once at the end of each	Inductive thematic

	participation in orientation session	**interview responses during debriefing session**	**the orientation session**	**instructional unit, total of 9 sessions.**	**coding of semi-structured interview**
	Medical learners' attendance at orientation session	**Attendance sign-in sheet**	**Researcher**	**At the beginning of each orientation session; 1 student each session, for a total of 9 sessions**	**Quantitative analysis of attendance sheet sign-ins**

Outcomes Research Questions

RQ1	Variable	Instrumentation	Data Source(s)	Data Collection Frequency	Data Analysis
	Medical learners' ability to exercise clinical judgement when treating a patient exhibiting SVT symptoms	LCJR (Lasater, 2007)	Medical learners participating in the intervention	Once at the end of each instructional unit, total of 18 sessions.	Independent *t*-test (*p*=.05) to analyze clinical judgement when caring for symptomatic SVT patient, assessment of clinical judgement as measured on the LCJR

	Medical learners' SVT knowledge acquisition	**SVT pretest-posttest**	**Medical learners participating in the intervention**	**Pretest before SVT intervention, Posttest after intervention total of 18 sessions**	**Paired sample *t*-test to analyze difference in pre-posttest scores and independent *t*-test between groups**
RQ2	**Variable**	**Instrumentation**	**Data Source(s)**	**Data Collection Frequency**	**Data Analysis**
	Medical learners' perception of self-confidence when exposed to SVT patient scenario	**Student Satisfaction and Self-confidence in Learning Questionnaire (SSLQ) (NLN, 2005)**	**Medical learners participating in the intervention**	**Once at the end of each instructional unit, total of 18 sessions.**	**Descriptive statistics to analyze self-confidence in learning when caring for symptomatic SVT patient**

					as measured on the SSLQ
RQ3	Variable	Instrumentation	Data Source(s)	Data Collection Frequency	Data Analysis
	Medical learners' perception of satisfaction using the IVR instructional delivery method	Semi-structured interview	Medical learners participating in the intervention	Once at the end of each instructional unit, total of 9 sessions.	Inductive thematic coding of semi-structured interview
	Medical learners' perception of satisfaction when exposed	Student Satisfaction and Self-confidence in Learning Questionnaire	Medical learners participating in the intervention	Once at the end of each instructional unit, total of 18 sessions.	Descriptive statistics to analyze self-confidence in learning when caring

	to SVT patient scenario	**(SSLQ) (NLN, 2005)**			**for symptomatic SVT patient as measured on the SSLQ**

APPENDIX F

Orientation Protocol Checklist

RESEARCH PROTOCOL CHECKLIST

1. BEFORE THE INTERVENTION

- ☐ Research subject informed that they can choose to stop at any time.
- ☐ Research subject informed of what is expected.
- ☐ Research subject adjusted for equipment
- ☐ Research subject oriented to VR environment
- ☐ Research subject provided 20 minutes to understand how the VR equipment works

2. DURING THE INTERVENTION

- ☐ Research subject assessed on clinical judgement
- ☐ Researcher logged any equipment issues/errors
- ☐ Research subject participated in the entire intervention

APPENDIX G

Functionality of Equipment Tracker

Date	Time	Equipment Issue	Resolved?	Details
2/25/2020	7:35	Oculus Go unit will not connect to iPad because the unit cannot connect to the Hospital's encrypted Wi-Fi	No	The Oculus Go has to be connected to Wi-Fi in order to screen cast the content. If it cannot connect then the observer will not be able to assess the participant in the SVT scenario because they will not be able to see what the participant is looking at and doing. Attempts to connect to the Wi-Fi and resolve the issue were not successful. Had to relocate the IVR experimental group Midland University's campus to access the Wi-Fi.
3/3/2020	11:19	The SVT software program quit and went from IVR mode to web browser mode.	Yes	Participant was forced out of the SVT scenario at the beginning of the intervention. While it is likely that the participant accidently pressed the exit button on the controller, the researcher did not observe this and so it was recorded as an equipment issue. The participant was placed back into the SVT scenario and there were no futher incidents.

APPENDIX H

Attendance and Participation Tracker

Participant	Attendance	Orientation Session	IVR Simulation	Semi-Structured Interview
1	Yes	Completed	Completed	Completed
2	Yes	Completed	Completed	Completed
3	Yes	Completed	Completed	Completed
4	Yes	Completed	Completed	Completed
5	Yes	Completed	Completed	Completed
6	Yes	Completed	Completed	Completed
7	Yes	Completed	Completed	Completed
8	Yes	Completed	Completed	Completed
9	Yes	Completed	Completed	Completed

APPENDIX I

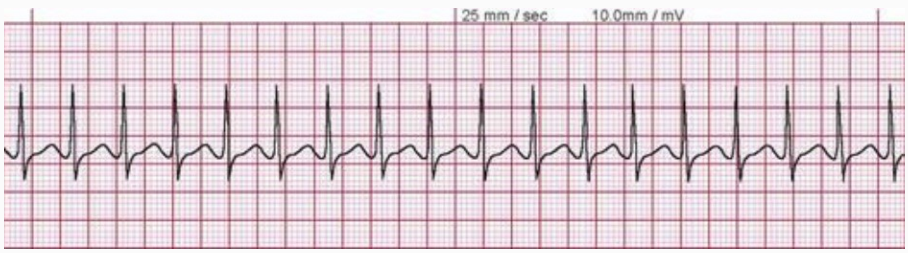
Posttest on SVT Knowledge

Answer questions 1&2 with the following scenario.

A 24 y/o F presents complaining of feeling light-headed and short of breath.

Her initial vitals are as follows: T 36.8 / BP 120/60 / HR 180 / RR 20 / SPO2 100% on room air.

You check an EKG which demonstrates the following:



1. Name the rhythm above

A. Atrial Fibrillation

B. Sinus Tachycardia

C. Ventricular Tachycardia

D. Supraventricular Tachycardia

2. What is the best (first) management strategy?

A. Beta-blockers

B. IV fluids

C. Calcium channel blockers

D. Carotid massage or Valsalva maneuvers

3. You attempt vagal maneuvers but the patient remains in what appears to be SVT. What medication should now be administered?

A. Adenosine

B. Amitriptyline

C. Atenolol

D. Amiodarone

You administer 6mg of adenosine and get the following EKG:

4. What is your next step in management?

A. Administer beta blockers

B. Administer calcium channel blockers

C. Transfuse

D. Re-assess vitals

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Stanford University, Stanford, CA
MOOC: Designing a New Learning Environment COC
Top 1% of 1125 enrolled students. Project finished in first place.

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